Usability Study of Mobile Groupware Applications: A Case Study of Mobile Meeting Scheduler

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Mobile groupware applications are to support users of different roles in completing tasks of mutual interests by operating mobile devices. Mobile Meeting Scheduler is an example of such applications. This software enables users of different parties to communicate with each other about the meeting time, venues, participants and subjects. The purpose of the software is to facilitate users setting up meetings by using their mobile phones. A preliminary usability study of Mobile Meeting Scheduler suggests that evaluation of such applications is challenging. The evaluators need insights into usability study methods for mobile groupware applications. An extensive literature survey shows that there is no directly applicable research on the subject yet. However, the analysis of Mobile Meeting Scheduler, its preliminary usability study and the relevant literature give implications on the important usability aspects of mobile groupware applications. The implications include also possible methods to conduct usability evaluations for mobile groupware applications. These implications will call for HCI researchers and practitioners to contribute further efforts to investigate practical usability study methods for mobile groupware applications.

Key words and terms: groupware usability evaluation methods, mobile usability evaluation, mobile collaborative application, usability engineering, use context and user-centred design.

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1 Introduction

Mobile groupware applications are becoming popular in enterprise management. Grundy et al. [2002] and Cisco Systems [2007] find that when business operations globalize more and more, organizations work more dispersedly. Mobile applications with groupware features are cost-effective solutions for efficient communications in organizations. They facilitate improved internal communication and productivity in organizations. Today advanced computing technologies [Divitini et al., 2004; Kurkovsky et al., 2004] have made it possible for many groupware applications to be run on mobile devices. However, most of the applications are not yet widely used. Serious usability problems are among the reasons.

The causes of the usability problems remaining in the groupware applications include the fact that the usability evaluation of mobile groupware applications is far from a straightforward task. There is no ready guideline or standard procedure yet for evaluating the usability of mobile groupware applications. Empirical studies related of usability evaluation techniques in context of a particular mobile groupware application development project are also few. Shared obstacles hindering these are several.

First, the mobile groupware applications are emerging types of software. Off-the-shelf products are rare. Second, the traditionally established usability evaluation techniques fail to support the identification of usability problems that are particular to groupware applications [Ellis et al., 1991; Baker et al., 2002; Pinelle et al., 2003]. Third, methodologies of evaluating the usability of mobile devices and applications are in early exploration stages [Halpert, 2005; Jokela et al., 2006; Jung et al., 2006; Nielsen et al., 2006].

Mobile Meeting Scheduler (MMS) is an example of mobile groupware applications. It is an asynchronous groupware system. It was under development by students from the Department of Computer Sciences at the University of Tampere as a Project Work course project from October 2006 to May 2007. The customer of the project was a telecommunication vendor.

MMS enables different parties to organize meetings with participants through a server-provided negotiation mechanism by operating their mobile phones. It aims to facilitate the efficient finding of timeslots that suit all invited participants by using their mobile phones. In addition, it allows groups of users to communicate with each other about the themes, venues and participant lists of meetings regardless of their locations.

The MMS usability evaluation is faced with the general hurdles hindering the usability study of mobile groupware applications, which were mentioned earlier. In this example case, one of the biggest problems was that the project development team had no possibility to contact directly the end users of the application because the nature of the project was confidential. This drawback limited the possibilities for studying users of the application. Consequently, the preconditions for the usability evaluation, which are requirements set in ISO 13407 [1999] and ISO 9241-11 [1998] were not complete in the MMS project.

The ISO instructions state that the usability evaluations of a product should be based on its predefined usability requirements. The analysis of use context which includes the characteristics of the target users, the tasks and the organizational and physical environment is the starting point for eliciting and specifying the usability requirements of software applications.

As a usability specialist for the MMS project, I organized an expert group walkthrough to review the MMS User Interface Design Specification document (MMS UI Specification) [Taus and Mäenalusta, 2007] in the early phase of the project. The walkthrough results showed that the usability requirements of the MMS are many faceted and complex. The experts with different backgrounds found very different usability problems based on the design document.

The divergence and the complexity of the usability requirements indicate that the established usability evaluation methods might not be sufficient to support the usability study of mobile groupware applications. The indication provoked me to consider how to integrate usability engineering into software project developments in order to support user-centred design for mobile groupware applications. The disparities of the walkthrough results led me to study and validate further MMS usability requirements from a mobile groupware application point of view. The variety of the evaluation methods applied by the experts motivated me to explore suitable usability evaluation methods for mobile groupware applications.

Existing literature [Lindgaard, 1994; Nielsen, 1993; Righi and James, 2007] about usability engineering and user-centred design focuses on exemplifying concepts of different design techniques. In fact, the literature does present case examples to explain the traditionally established usability evaluation methods such as heuristic evaluation and user testing. Similarly some researchers have contributed their efforts to develop various groupware specific usability evaluation methods [Baker et al., 2001; Pinelle and Gutwin, 2002]. Additionally some other studies [Kaikkonen et al., 2005; Kraub and Krannich, 2006; Trevor et al., 2001] have aimed at finding solutions to evaluate the usability of mobile devices and applications. As a result, derived methods of established inspection techniques and user testing in context of mobile devices and groupware applications are being developed concurrently.

However, case studies of early usability work to support user-centred design of mobile groupware applications under development are missing.

As a result, I decided that the focus of this thesis is to explore the important usability aspects to evaluate in mobile groupware applications in the course of user-centred design. In addition, I will investigate alternative ways of conducting the usability evaluation of mobile groupware applications under development in order to bring out products of good usability. The MMS case study will be the base of this exploration and investigation.

The MMS preliminary usability experiment report, survey and discussions in the thesis will directly help the further design of MMS to be more human centred. They will also offer general insights into organizing usability activities for developing similar mobile groupware applications. Furthermore, the case study will contribute as an example for HCI researchers and practitioners to design usability engineering activities for developing user-centred mobile groupware applications. Above all, one of the objectives of the thesis is to stimulate HCI researchers and the practitioners in the mobile field to come up with more studies on related topics.

In this thesis, I will introduce MMS, its preliminary usability studies and challenges for usability evaluations in Chapters 2 and 3. Based on these, in Chapter 4, I will examine the related work carried out about usability studies of mobile collaborative applications. The purpose of this chapter is to find out important aspects and alternative ways in evaluating the usability of mobile groupware applications such as MMS so as to best support user-centred design of such applications. Before I conclude the thesis, in Chapter 5, I will summarize and discuss the important aspects and alternative ways for mobile groupware application usability evaluations.

2 Mobile Meeting Scheduler overview

This chapter will introduce the MMS product development environment, its functionality and the interactions. It will report the preliminary studies on the usability of MMS. Based on the studies, it will analyze the findings and implications towards further usability engineering activities of MMS in its present development project.

2.1 MMS development environment

MMS was under development by the students from the Department of Computer Sciences at the University of Tampere in the Project Work course from October 2006 to May 2007. The software targets to enable different parties to communicate with each other about the meeting time, venues, participants and subjects. It is a mobile client-side application. It runs in S60 mobile phones with negotiation via an application server (AS).

The MMS project development model was Waterfall [Royce, 1970] having a series of modular phases. The phases span from the functional requirements analysis, to the software design, implementation, testing and maintenance. The output of each phase is a specification for the work of the next phase. For instance, the software design phase outcome is a design specification document for the implementation phase.

The project schedule was a reflection of the Waterfall development model. Table 1 is a screenshot of the schedule in the form of a Gantt chart. The table presents the timeline and tasks for developing MMS at different phases throughout the project lifecycle.

According to the table, phase one is to make a project plan. This phase mainly deals with preliminary studies of the project development environment including implementation technologies and risk analysis. It identifies project constraints and objectives. It puts forward an initial scheduling for the project.

The second phase is to define requirement specifications including user interface (UI). The study of use cases will be the main input to defining all requirement specifications. The outputs of this phase are the UI plan and software requirements specification (SRS).

The third phase is about designing. Within this phase, all the design documents including the UI design should be ready according to the requirement specifications and the UI plan.

The fourth phase is implementation when the project should focus on the coding of user interface, business logic and application. The coding will be done all in one go in reference to the design documents. After the implementation completes, the project moves onwards to the testing phase—the fifth phase.

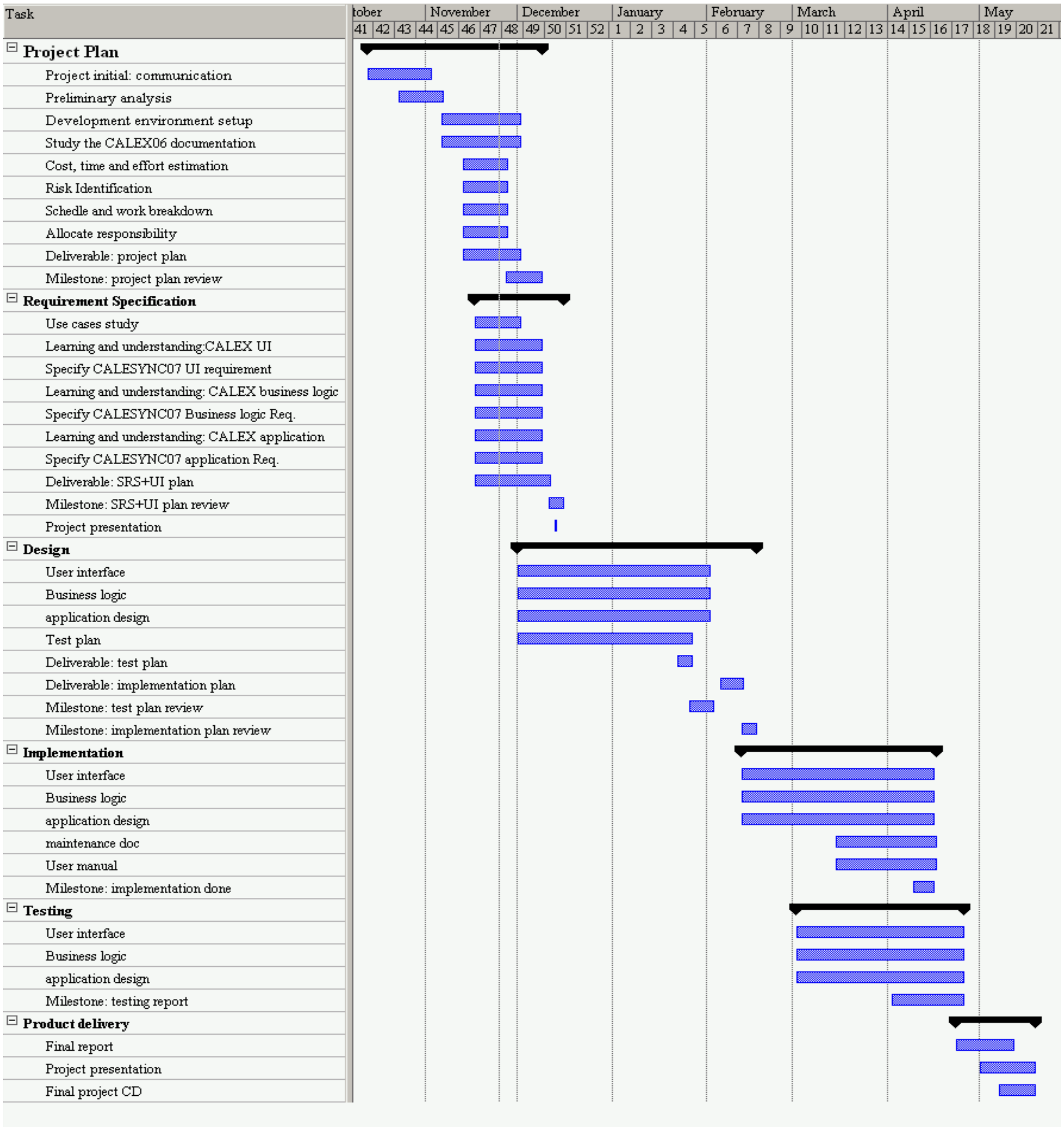

Table 1. MMS project development plan [Yang et al., 2006].

The table further shows that the UI tests are planned to be carried out together with functionality tests. The final phase is the product delivery phase which comes right after the test phase.

The project plans to proceed in sequence of the different phases from top to down as listed in the table. The requirement elicitation, design, implementation and testing appear to be independent from each other. It seems that there is no time reserved for fixing the design problems revealed by the tests. Iteration looks unlikely.

As for the development technology, the MMS project adopted the object oriented method and Symbian C++ programming language. However, the project team members had little previous experience in programming mobile applications by using Symbian language. They were 3rd and 4th year students of computer sciences majoring in computing and interactive technologies. My assignment in the project was a usability specialist from the Usability Team. The project regarded me as an external resource.

As for MMS functionalities, the customer of the project presented use cases in written form. The use cases were the most important original sources for the elicitation of software requirement specifications. No other source was available. However, the primary goal of MMS development was to meet the customer requirements about the application.

2.2 Functionalities and interactions

MMS users take three roles—meeting organizer, required attendee and optional attendee.

The main features of MMS are creating, sending, receiving, updating, accepting and declining meeting invitations. The application enables users to compile and send meeting invitations concerning meeting subject, time and place to attendees by using a buddy list—a shortcut to add addresses of groups. It allows meeting organizers to send a query about the availability of all attendees at certain proposed timeslots to the calendar AS. In turn the AS will inform the mutually available timeslots to the organizers who will decide about the actual meeting time. The attendees have a choice of accepting or rejecting the invitation they receive. The organizers reserve the modification right to the meeting invitations they have sent out.

The above described MMS functionalities indicate that MMS is an application "of distributed interaction" [Ellis et al., 1991, p.41]. Ellis et al. explained that examples of such applications include electronic mailing systems and calendar systems. They are also known as asynchronous groupware applications.

2.2.1 Use cases

As mentioned in Section 2.1, the customer of the MMS project provided the functionality requirements for the application in terms of use cases. The following use cases convey the major functionalities of the application. The entities in the use cases are user, organizer, attendee and AS. The user refers to a general user of the application. Organizer indicates a user who organizes a meeting. Attendee is a user who is invited to a meeting. Sometimes the attendees are referred to as invitees as well. The attendee can be a required or an optional one. The AS is the application server that hosts the business logic of the application at the server side.

Setting up buddy lists. The user can set up his or her buddy list on the AS Web interface. A buddy list is an enumeration of the "friendly" users in a context. There may be one buddy list for the family members and another for colleagues. Time availability for new appointments can be set for each buddy list. For instance, Mo-Fri 08-17 is available for colleagues.

Querying for free timeframe. An organizer can initiate an appointment and query member(s) of a buddy list to get an appropriate timeslot that is available for all of the required participants (and if possible, for the optional participants, too).

Invitation without attendees means a pure time reservation in the organizer's own calendar. Communication of querying for free timeframe is done only between the organizer and the AS.

Sending invitation. An organizer can send out an invitation for a meeting set up as described above. The organizer sends the invitation to the AS which distributes the message further to the attendees.

Responding to invitation. An attendee may accept or decline a meeting invitation received. The attendee communicates the decision to the AS which automatically forwards the message to the organizer only. The decision does not go to other attendees.

Updating or deleting an appointment. An organizer can change details of an appointment. The organizer can also cancel an arranged meeting. The organizer communicates the changes in subject, location or attendees and the deletion of an appointment to the AS. The AS will further send the information to the attendees.

Updating invitation status. Attendees can request an update on the status of an invitation from the AS in order to check the other attendees' decision (accept or decline).

Compiling new invitation. MMS enables a meeting organizer to compose meeting invitations containing meeting subject, time, place, required attendees and optional attendees. The meeting subjects and location will be input by users manually via mobile phone keyboard. The list of attendees will be available upon requesting the buddy list. The organizer will select the timeframe for the meeting on basis of the timeframe query results provided by the calendar AS. The invitation draft will be available for viewing before the organizer decides to send it to attendees via the AS.

2.2.2 Interactions

MMS provides different functionalities to mediate interactions and communications between a meeting organizer and meeting attendees through the calendar AS.

There are two channels of direct interactions in the application. The interaction between the meeting organizer and the calendar AS is one channel while the contact between the meeting attendees and the AS is the other. The success of the communication between all the entities in this application seems to depend mostly on the logical and clear-cut interactions among them. Figure 1 shows the functions and main interactions augmented by MMS.

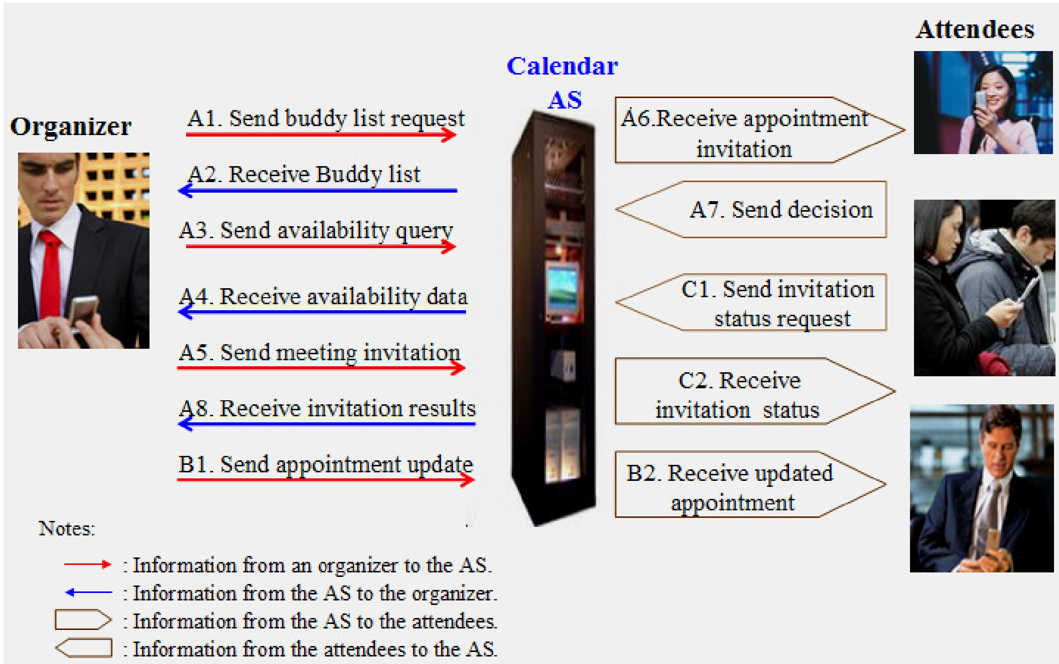

Figure 1. MMS functionalities and interactions.

The meeting organizer mainly interacts with the attendees via the calendar AS. In Figure 1, A1, A3, A5 and B1 indicate that an organizer sends to the calendar AS the buddy list request, attendees' availability query, meeting invitations to attendees and updated invitations to attendees. A2, A4 and A8 are respectively for a meeting organizer to receive information regarding the buddy list, the attendees' availability, and the meeting invitation acceptance from the attendees via the calendar AS.

The attendees also send and receive information via the AS only. A6, B2 and C2 in Figure 1 describe respectively that attendees receive meeting invitations, updated invitation and the invitation status about the meeting appointment from the AS. A7 represents that attendees send their decisions about accepting the invitation or not to the AS. C1 indicates that attendees send their inquiry about the invitation status to the AS.

Before organizers distribute meeting invitations, they need to send a request to the AS for a buddy list of their invitees. The list is a shortcut to respective groups of mobile phone numbers defined by the organizers. The organizers must store the list at the AS beforehand. When organizers receive the buddy lists from the AS, they will check the available timeslots that are common to all the invitees by sending a free timeframe query to the AS. The server will reserve and inform the organizers of the results of the available timeslots query. After the organizers receive the available timeslots for all the invitees, they can choose the most suitable time and send the meeting invitation to invitees.

When invitees receive a meeting invitation from the organizers via the AS, they can decide if they reject or accept the meeting invitation. The invitees can inform the organizers about their decisions by sending a message of "Yes" or "No". The invitees can also judge if they are required or optional attendees from the invitations they received.

The organizers have the right to update their sent meeting appointments by sending an updating request to the AS. They can cancel or change their proposed appointments regarding the timeslots, the meeting subjects or the meeting venues. The invitees will receive the updated information from the organizer.

Attendees can send invitation status checking requests to the AS. They will get information about the priority of the invitation. The sooner the meeting time is the higher its priority. In addition, MMS has a function to remind users of the coming-up meetings.

2.3 MMS UI specification evaluation

In the MMS project, the UI specification was the communication document bridging the design and the implementation. In the UI design phase, when the MMS UI specification document [Taus and Mäenalusta, 2007] was ready, the project requested me to evaluate and review the specification. The project intended to have the evaluation results as the input for improving the UI design of MMS.

Therefore, the purpose of the UI specification evaluation was to support MMS UI design to be user-centred providing users with ease at learning and using before the implementation started. In other words, the project regarded the UI specification review as the preliminary usability evaluation of MMS.

Hereinafter, I will report the MMS UI specification evaluation activities and results. I will also analyze the findings and implications that this evaluation has for the further usability engineering work of MMS development in its present project cycle.

2.3.1 Evaluation methods

The evaluation source was the MMS UI specification version 0.1. As a matter of fact, this version of the specification turned out to be only a collection of rough graphical sketches of MMS UI. It left away the description of MMS information flow. It neglected to mention the interconnection between different UI views and user tasks of the application as well. No prototype was available yet. The project requested the evaluation and result report to be ready in seven working days. The evaluation results were expected to improve the graphical user interface design of MMS before coding started.

The project development situations stated above suggested that the consideration of multiple usability evaluation methods was necessary in evaluating the MMS UI spec. It seemed that formal user testing [Dumas and Redish, 1993] was too early in this situation when no mock-up of the system was ready. The Heuristic Evaluation rules proposed by Nielsen [1994] might help to examine the graphical views proposed by the

UI specification from a single user's point of view. However, the rules might not support well to examine if the information flow and the task handling of MMS meets the user's requirements. Conversely, the cognitive walkthrough [Wharton et al., 1992; 1994] and its variant contextual walkthrough [Po, 2003] would be good theory foundations to analyse the information flow and task organization of the MMS. The results indicate if the UI can support users effectively in seeking necessary information and using the relevant functionality to achieve their goals. Nevertheless, such walkthroughs might not touch issues governed by the S60 platform UI design guidelines. Table 2 lists the important instructions for designing and evaluating S60 platform UIs, which are available at http://www.forum.nokia.com.

Similarly, the S60 platform UI design guidelines listed in Table 2 alone did not seem to be sufficient enough to predict all of the usability problems hidden in the UI specification. The pluralistic walkthrough [Bias, 1994] involving experts of different background including target users and design engineer could generate brainstorm style opinions regarding the UI sketches provided in the MMS UI specification. However, the MMS project had no contact with the end user. On the other hand, this method requires the evaluation moderator who is in charge of the evaluation activities to design a set of tasks and questions for the experts. As a result, the tasks and questions will direct and limit experts in identifying only certain type of usability problems.

Guidelines	**Date of publication**
S60 Platform: Development and Quality Assurance Process Guideline	October 17, 2006
S60 Platform: Use Case Creation Guideline	September 29, 2006
S60 UI Style Guide	November 9, 2005
Flash Lite: Visual Guide	July 6, 2006
User Experience Checklist for Java™ ME Applications	March 16, 2005
S60 UI Specification Guideline	May 8, 2005
Introduction to S60 UI Components	May 8, 2005

Table 2. S60 Platform UI design and evaluation guidelines at http://www.forum.nokia.com.

It would be ideal to conduct several evaluation sessions on basis of the above mentioned methods in order to get an overall picture about the usability problems buried in the UI specification. Unfortunately this was not possible because of the resources and the time schedule of the project.

After analysing the overall situation of the project and different assessment methods, I proposed to have a distributed expert group evaluation of the MMS UI specification. I recruited a group of usability experts of various competence backgrounds for the evaluation. Experts were free to choose methods they deemed to be suitable to inspect the MMS—a mobile groupware application. Figure 2 presents a general view about the process of the distributed expert group evaluation.

The first step was to distribute an evaluation package to all the experts. The package consisted of PDF documents of the MMS UI specification version [Taus and Mäenalusta, 2007], MMS software requirements specification [Mäenalusta et al., 2007], MMS project plan [Yang et al., 2006] and customer requirements. Above that, I drafted separate instructions explaining the process of the evaluation activities and sent them to all the experts.

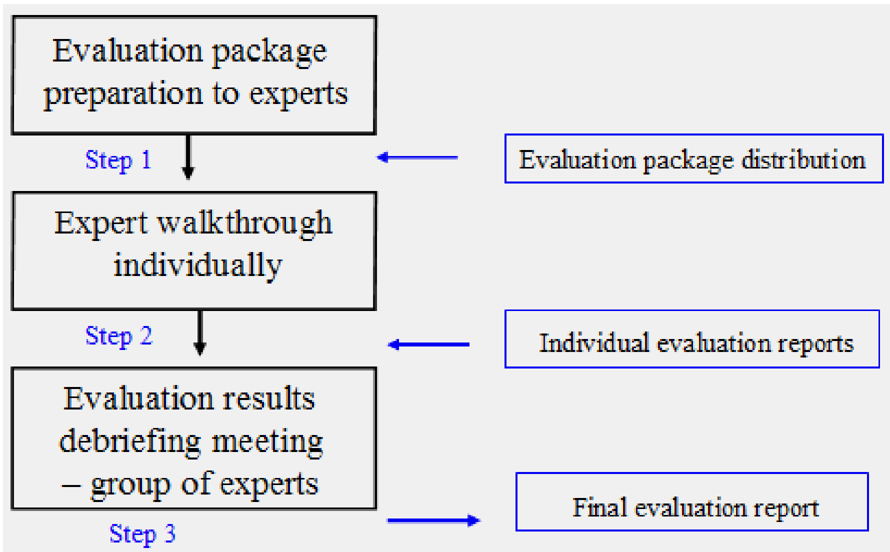

Figure 2. Process of evaluating the MMS UI specification by individual expert walkthroughs.

The instructions specified that the evaluation source was the MMS UI specification version 1.0. All other documents included in the package were background information for experts' references only. The instruction also stated that the primary objective of the evaluation is to examine if the graphical sketches in MMS UI specification reflect the requirements of the user and the task in respect to MMS functionality. Some of the sketches will be illustrated in Section 2.3.3. Another objective was to analyze and elicit the usability requirements for further usability work in the MMS project.

The instructions suggested the experts to have free choices about the inspection methods they deemed as suitable to evaluate the usability issues of mobile groupware applications. This was based on the consideration that different evaluation methods will result in discovering different aspects of usability problems in an application [Ivory and Hearst, 2001]. The instructions did not include any specific evaluation task questions either. This was to avoid imposing constraints to experts in the evaluation.

The second step was the individual expert walkthrough of the MMS design. Experts had about five days to study and inspect the specifications on their own. They were supposed to record their findings in detail but in free style. They submitted their individual evaluation reports to me before the debriefing meeting.

The third step was to debrief the individual expert evaluation results. I called up all the experts for the debriefing meeting. In the meeting, experts presented and justified briefly the usability problems they had found. They also discussed how seriously the problems might affect the usability of the system.

2.3.2 Expert team

The expert team consisted of four usability experts including myself. The task of the expert group was to evaluate if MMS design was human-centred on the basis of its UI specification. The invited experts were Jack, James and Minnie. These names are only for reference purpose in the thesis, not their real names. All the experts have gone through basic courses of usability evaluation and graphical user interface design. They were all at their senior years of master degree program for Interactive Technology. More information about the competence of all the experts is given below.

Jack has more than five years of web-based user interface designing experience. He has broad knowledge about groupware usability. He is familiar with different usability inspection methods including Nielsen’s Heuristic Evaluation [Nielsen, 1994] and cognitive walkthrough [Wharton et al., 1992; 1994]. He has also studied and practised the contextual walkthrough [Po, 2003] technique – a variation of the cognitive walkthrough.

James is a Symbian developer from the MMS project development team. He was one of the authors of the MMS UI specification to be evaluated. He understands the design constraints of MMS on basis of the development environment. He also has basic knowledge about usability in general. He has experiences with the Heuristic Evaluation method from his previous courses at the University.

Minnie has more than three years of experience with different kinds of mobile applications and mobile devices of the Symbian 60 platform. She is an experienced user of Nokia S60 mobile phones. She has practiced the Heuristic Evaluation technique for two years in her studies.

As a member of the expert team and the usability specialist of the MMS project, I have some experience with mobile groupware applications. I am aware of groupware requirements such as “effective access control” [Ellis et al., 1991, p. 55]. I have also experience in evaluating the usability of different kinds of applications. These include web-based multi-user language learning system and the electronic library system Netlibrary. Additionally, I studied the Symbian 60 UI design guidelines listed in Table 2 because they are relevant with the MMS implementation platform.

Moreover, I worked as the facilitator of the expert group evaluation being responsible for planning and organizing the whole activities concerned. In the following subsections, I will summarize the evaluation results with improvement suggestions to the MMS development team.

2.3.3 Findings of individual experts

Jack reported to have used Contextual Walkthrough [Po, 2003] in evaluating the MMS UI specification. He identified the usability problems on the basis of task analysis and task scenarios referring to predefined use cases in the customer requirements.

Jack's results had two categories. The first category covered his finding about the incompleteness of the MMS UI specification document. This might cause the end-product to have an illogical construction of the UIs. The application might be far away from the users' mental model [Norman, 2002]. Users with common knowledge about arranging meetings would have difficulty in understanding and using the intended functions of the application. He also pointed out that the missing contents were the information flow of the application on the basis of the use cases, the UI state description and the data handling of the product. The information flow means the indication of what kind of information goes to whom. It describes how users respond to the information they receive. It shows how to indicate the state of the application to users of different roles.

Figure 3. New meeting view [Taus and Mäenalusta, 2007].

The second category included 37 usability problems which were identified from the screen views presented in the MMS UI specification. Most of the problems hindered users from completing tasks intended by the specification. Many screen views conveyed misleading instructions to users for completing certain tasks intended by the specification. For instance, the "New meeting view" shown in Figure 3 did not indicate users to fill in any data in any field. Rather, this UI view looked more like a review of a new meeting message.

Main View displayed in Figure 4 does not provide users access to the different functions of the application as users are used to. Instead, it resembles a summary of a meeting list. Jack also commented that the screen views seemed to be merely separate individual images without internal coherence. In his opinion, these phenomena made the evaluation almost impossible.

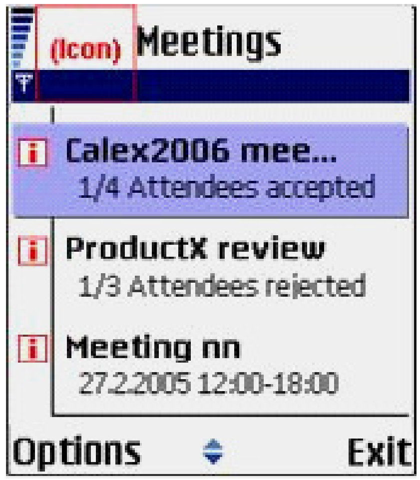

Figure 4. MMS main view [Taus and Mäenalusta, 2007].

The references that I applied to evaluate the MMS UI specification were the S60 platform related industrial guidelines and international standards on creating UI specifications. They include S60 platform related UI designing and evaluating guides and the usability checklist as listed in Table 2. I also borrowed the cognitive walkthrough [Wharton et al., 1992; 1994] philosophy and Nielsen Heuristic Evaluation rules [Nielsen, 1994] in reviewing all the screen views and their descriptions in the specification.

My personal findings were in two parts. The first part concerned the incomplete content of the MMS UI specification. I found that the specification did not describe the overall information flow of the application. The description about the UI state and data handling of the application was missing. I also noticed that the specification did not mention how MMS handled the mobile phone generic use context—"interruptions and multitasking" as mentioned to be important in the Use Case Creation Guideline listed in Table 2. In MMS, the "interruptions" refer to sudden phone calls, messages receiving/sending, battery losing or accidental operation mistake by users when they are operating the application on their mobile phones. Multitasking means users work on the MMS while turning to operate another application. When they return to the MMS, the previous status should remain as unchanged.

In addition, I recognized that the UI screens did not provide mechanisms to support interaction and communication between users of different parties. The UI design in the specification seemed to have considered only single users' point of view.

Figure 5 shows an example of the problems I found. The figure is a screen view for a meeting organizer about the time query feedback from the AS. The screen does not inform if the listed timeslots were suitable for all the required attendees, or all the invited including the optional ones. The screen does not show either if the AS has reserved the listed available timeslots till the meeting organizer makes a selection.

Figure 5. Meeting time query feedback from the AS [Taus and Mäenalusta, 2007].

The second part of my findings contained 45 usability problems regarding the screen views in the UI specification. Most of them dealt with the ambiguities of the system status. As an example, Figure 6 shows the screen view received by attendees about incoming meeting invitations.

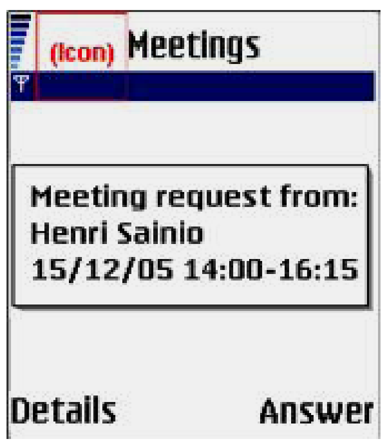

Figure 6. Attendees' view about receiving a new meeting request [Taus and Mäenalusta, 2007].

In Figure 6, the left soft key is labelled as "Details". However, the specification did not describe what "Details" will do. Secondly, the screen message shows only the meeting organizer and the time. This information might be too simple for attendees to decide if they would like to attend the meeting or not. Other information such as meeting topics, other participants and meeting place might also be necessary.

On the other hand, the specification did not specify where the answer would go once the "Answer" key was pressed. It did not mention if the answer would go to the meeting organizer, the AS, or the meeting host in case the meeting host is different than the organizer. Alternatively, one might think if this screen meant only to check the time availability with individual attendee before the meeting organizer could decide the meeting time. This seemed to be in contradiction to the customer requirement that the time query went through the AS. Furthermore, the design did not define any notification mechanism [Ellis et al., 1991] for users to notice the incoming invitation message. There is no way to help users distinguish if the invitation is from an important organizer or not.

Figure 7 provides another example. This is an organizer's screen view of receiving invitation acceptance from invitees. In this view, there is only information about who has accepted or rejected the meeting invitation. There is no indication about if they are optional or required attendees. Information regarding the meeting time and place is also missing, which might cause difficulty for the organizer to retrieve the invitation. The organizer would have no chance to know if any one has not even reacted to the invitation yet. This might be communication demise among users of different roles.

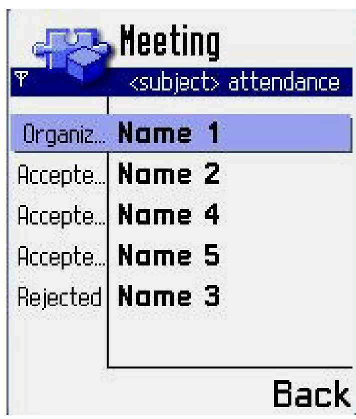

Figure 7. Organizer's view about invitees' acceptance to attend a new meeting [Taus and Mäenalusta, 2007].

Overall, the operations of some of the tasks to be completed by individual users in MMS design are impractical. Among many impractical examples, the application does not embed any calendar function. It does not include an access to any outside calendar resource either. When organizers are in the process of sending the timeslot query to the AS, they might not have a calendar at hand. If the organizers want to go to check their calendar provided by another application in their mobile phones, they might lose their half-way drafted meeting invitations.

Equally, users might face difficulty in completing some individual tasks due to poor UI design. In the specification, Figure 3 on page 13 intended to describe the function of drafting new meetings as well. The UI view does not indicate which fields users need to fill in before they can send the invitation. The menu item "Options" does not indicate how the users should proceed in drafting the contents of new meetings. For example, users will have difficulty in figuring out what “the first possible date” means and how to obtain the information. The view shows also that the users have no opportunity to save or send the meeting invitation either. They can only cancel the meeting invitation. In short, this interface does not support users to create a new meeting message as the UI specification intended to.

James and Minnie referred to the Nielsen [1994] Heuristic Evaluation rules for the assessment of the MMS UI specification. For convenience of reference, Table 3 is to reproduce Nielsen’s ten heuristic rules applied in the assessment.

James and Minnie did not report that the evaluated source was incomplete in content. They did not point out that the state change of the interaction functions and the flows of each screen view were missing in the UI specification either. Their reports focused on the intuitive findings of the individual screen views presented in the specification in comparison to Nielsen’s heuristics. Surprisingly, their concrete findings differed a great deal from each other.

Rule	Heuristic Evaluation Rules	Abbreviation
1	Visibility of system status	Visibility
2	Match between system and the real world	Familiarity
3	User control and freedom	Freedom of choice
4	Consistency and standards	Consistency
5	Error prevention	Error prevention
6	Recognition rather than recall	Recognition
7	Flexibility and efficiency of use	Flexibility
8	Aesthetic and minimalist design	Aesthetics
9	Help users recognize, diagnose, and recover from errors	Error message
10	Help and documentation	Help

Table 3. Heuristic Evaluation rules [Nielsen, 1994].

James mentioned six points to be problematic with the present design. Five of them were not in line with the familiarity rule of Nielsen’s heuristics listed above. The other point was about the design constraints set in the S60 platform.

In contrast, Minnie spotted 20 usability problems of different types. Most of the problems simultaneously infringed more than one rule. Eight problems were about the consistency of form design and soft key labels. Seven problems related with the familiarity and error prevention rules. Five broke the rules of visibility and freedom of control. Figure 8 represents the typical problems Minnie reported. According to S60 UI design convention, the soft key labels “Select” and “Back” are not used as a pair of keys on the screens of mobile devices. She suggested that the left soft key label “Select” should better be changed into “Cancel” in case of Figure 8 screen view for sake of keeping Nielsen’s rule of familiarity.

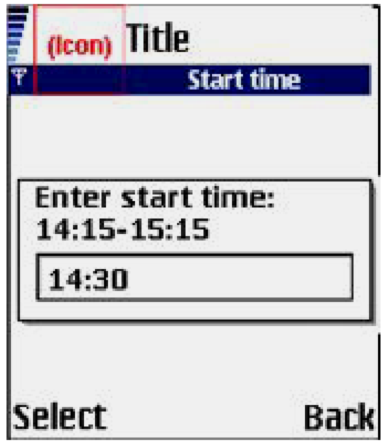

Figure 8. Meeting organizer’s view of entering meeting start time [Taus and Mäenalusta, 2007].

2.3.4 Combining individual findings

Upon analyzing findings of individual experts, I combined all of the MMS UI specification evaluation results obtained by each evaluator. Table 4 is a summary of the combined obtained results. The table shows that the experts together identified 116 problems ranging from eleven aspects. Problems occurred mainly in areas concerning information logic constructions, the single user interface, multi-party collaboration and mobile phone use context. They might indicate that the end product contains usability problems of different severity.

As a matter of fact, Table 4 reveals that none of the identified usability aspects was shared among all the four experts causing that prioritizing problems was almost impossible before the debriefing meeting. One of the most important reasons for this might be that experts applied different evaluation methods and guidelines. In addition, the competence difference regarding usability evaluation among the experts proves to have an effect [Hertzum et al., 2002; Jacobsen et al., 1998].

Aspects	Problems	Evaluators			
		Jack	James	Minnie	Wen*
1	Overall information flow in MMS	5	0	0	3
2	UI state description	8	0	0	11
3	Data handling	5	0	0	5
4	Single user task logic	10	5	12	0
5	Collaborative task logic	0	0	0	10
6	UI graphic presentation from multi-party users' point of view	2	0	0	10
7	UI graphic presentation from single user point of view	7	0	0	0
8	S60 UI style	0	0	0	2
9	S60 UI components	0	1	8	3
10	Mobile application interruption	0	0	0	3
11	Mobile application multitasking	3	0	0	3
	Total number of problems	**40**	**6**	**20**	**50**

*** Wen is the author of the thesis.**

Table 4. MMS UI specification evaluation results of individual experts.

Consequently, the debriefing meeting seemed to be critical in generalizing the final results of MMS UI specification evaluation. In the meeting, the experts supported their findings in reference to their inspection methods and guidelines. James argued that the UI sketches were self-explanatory in regard to the information flow of MMS. He also confessed that it was not easy for him to locate any problem from the UI specification as he was one of the authors of the document.

It is far from easy to distinguish if the difference of the experts' overall competence or the choice of inspection methods influenced more to the individual evaluation findings of the experts. James and Minnie using Heuristic Evaluation [Nielsen, 1994] technique got quite different results. Minnie identified many more usability problems than James. This might be due to that Minnie was an external resource to the MMS project and James was one of the developers of the application being aware of the technology constraints. Therefore, Minnie reviewed the UI specification on the basis of pure usability point of view while James was restricted by the system development techniques such as software development tool kits provided to the project.

However, experts with more knowledge and experience with groupware issues tended to identify more usability problems about the interference between users of different roles and the interrelationship between different UI views. On the contrary, the other experts spotted more problems about the UI components in each screen in terms of the inconsistency, visibility and feedback. Nevertheless, the expert who included S60 specific evaluation guidelines in the evaluation found most problems particularly pertinent to the usability of the application.

2.3.5 Final results and implications

It was hard to reach a mutual understanding about the MMS usability problems or their severity. The debriefing meeting assisted experts to agree upon 30% of all the concretely identified problems. The problems finally agreed on were results of extensive discussions on the basis of multi-disciplined evaluation principles as mentioned. Moreover, all the expert evaluators contended that MMS usability depends heavily on the overall functionality-based information flow of the application, the UI state change sequence from user interaction point of view and the data transferring process. In other words, experts agreed that MMS usability evaluation should assess these.

Altogether experts identified eleven aspects of usability problems as shown in Table 4. I summarized these problems into five major categories. They are logic flow of tasks, UI state change sequence and data transferring; interaction between multi-party users; multi-party user interface; single user interface and mobile use context.

To sum up, these findings indicate that UI screen views in MMS UI specification appear to be lacking coherence without a description of the UI state change sequence or a clear definition of the logic flow as shown in Figure 1 in page 8. The experts did not get the logic flow or the UI state change sequence as reference during their evaluation of the UI specification either. This might have created more difficulty for experts in evaluating the UI specification.

The findings further show that the end-users might even have no clue about how to start the application. Users might not be able to complete certain intended tasks. All these will most probably compromise the usefulness of the application.

The negligence of creating a mechanism for supporting the interaction and communication between users of different parties to carry out collaborative tasks will create a gap between the real world mental model and the user interface.

The inconsistency, poor feedback and lack of visibility in the user interface graphic design will not support users in learning and using the application. Instead, these flaws will be obstacles for users to complete their intended tasks individually and in a group. For instance, after an organizer sends out a meeting invitation to all the attendees, the attendees should reply about their attendance. If the meeting invitation content or the sending and receiving logic is not self-explanatory, users' mutual goal to settle meeting arrangements will fail to work.

The failure of taking the mobile use context into consideration will result in an unpleasant user experience. It will also affect users in reaching their targets with the application.

The five categories of usability problems suggest that the MMS functionalities should be arranged logically so that users feel that learning to use MMS is easy. The logic refers to the users' mental model [Norman, 2002] of the real world. The application should include all the functionalities that users need to complete their tasks of arranging meetings. Otherwise, users will find the application useless. The findings also reveal that MMS should take into consideration the interactive communication between users of multi roles. In addition, the application should be aware of the users' needs to operate individual tasks in painless efforts.

The evaluation results also predict that MMS usability requirements are many faceted. The elicitation and definition of the requirements should take place before other usability activities in the project development lifecycle.

Naturally, the complicacy of the evaluation findings and the diversities of inspection methods applied manifest that one-time usability assessment of MMS will not be the best way to support the user-centered design of the application. Rather, the user-centered design of MMS requires a series of usability engineering activities to cope with different phases of software development. The designing and deployment of these activities might be demanding. Reasons for these include that it is not clear how and what to evaluate regarding the usability of MMS. Its requirements need to be researched and specified. The project development environment seemed to set constraints to the usability engineering of the project as well. I will discuss these more in Chapter 3.

3 MMS usability evaluation challenges

The MMS UI specification evaluation event reported in Chapter 2 illuminates the challenges for MMS usability activities. In this chapter, I will investigate further these challenges.

3.1 Immature evaluation methods

A variety of methods must be used to evaluate the various aspects of MMS usability. The methods should cover issues from single user interface, groupware user interface and mobile device user interface point of view. The selection of usability methods for the MMS project requires comprehensive study of various usability evaluation techniques and close examination of MMS usability requirements. In addition, creative planning is obligatory in selecting usability methods for the project in question. The traditionally adopted usability inspection methods such as Nielsen's Heuristic Evaluation alone do not seem to be effective in identifying usability problems related with the user interactions in mobile context.

Grudin [1988; 1994] asserts that it is much more complicated to evaluate the usability of collaborative applications than that of single-user applications. One of the common factors is that users of these applications have more than just one role. The users might also have different computer literacy background, preferences and requirements regarding user interfaces. Compromising some user's needs to the other might be risky in designing collaborative applications.

Likewise, the organizational, social and cultural influences of groupware applications are beyond those of single user applications. As an example, it might take longer than any realistic period of time and resources in a project to learn about the "Critical mass and Prisoner's dilemma problems" [Grudin, 1994, p. 96] commonly observed in groupware systems. Interpreting and generalizing the cause and consequence of such problems might require long term field observations involving a great number of people in different sites. The logistics involved in a groupware evaluation project might be tremendous. The results might not even be reliable.

The study of Kraub and Krannich [2006] confirms that usability evaluation of mobile devices and applications requires different methods than those established on basis of the research about desktop/laptop PCs. Most mobile devices are handhelds with small screens while desktop/laptop PCs are placed on desks and have comparatively bigger screens. The physical features of mobile devices are more device-specific in comparison to desktop/laptop PCs. The use context of mobile devices and applications is dynamic in respects of location, environment and social ethics. Jones and Marsden [2006] also denote that mobile computing is a new branch. The design of most mobile devices and applications has no precedent.

However, only a few researchers and HCI practitioners have tried to study the field. Beck et al. [2003] surveyed major HCI publications for studies that discussed HCI issues in mobile devices and applications between 1996 and 2002. They found 114 papers of the area. Only 50 out of them related with usability evaluations. A majority of the 50 studies adopted evaluation techniques developed for desktop systems. As a consequence, usability methods of mobile applications have not yet been well studied.

It seems that selecting usability evaluation methods for mobile groupware applications will have at least three times more challenges than for applications of single users, groupware or mobile alone. This might be one of the important reasons why so far there is little research directly about evaluating the usability of mobile collaborative applications. Even fewer studies focus on evaluating such applications in order to support user-centred design in a software project development environment.

As a result, the study of usability evaluation techniques and ways to implement usability engineering in context of MMS is an exploration in the field. A comprehensive review of related work carried out so far in the field might help to understand the topic better. To this end, I will concentrate on surveying the previous work in the field in Chapter 4.

3.2 Constraints in the MMS project environment

In addition to the challenges of justifying suitable evaluation techniques, MMS is facing many other overwhelming obstacles of usability evaluation.

According to ISO 9241-11 [1998] and ISO 13407 [1999], the preconditions of software usability evaluation are to identify the usability goals, to specify the use context of the software and to determine the usability measures.

The usability goals are the targets a software product intends to achieve. They indicate the specified target group of users to complete predefined tasks in the specified environment.

The use context denotes four aspects of determinants which are product user, task, equipment and environment. The contexts of user addresses in detail the needs and characteristics of the intended users. Task context concerns the activities involved for users to complete tasks mediated by the software. The equipment determinant takes into account the performance and physical characteristics of the hardware that runs the software product. The working place environment, the ambient condition, cultural constraints, organizational rules and social etiquette are examples of the environment aspect in the use context.

The usability measures refer to the “effectiveness, efficiency and satisfaction” [ISO 9241-11, p. 11] that the software product produces to its intended users. The effectiveness is to measure the accuracy when users use the product to complete the intended goals. Efficiency is the measurement of effort and resources to reach certain effectiveness level. Satisfaction is to measure the users' opinions and satisfactory level of using the product. The choice of the usability measures should depend on the usability goals of the software project.

In the MMS development project case, the project did not set the usability goals by the time of evaluating the UI specification. There was not sufficient information to explicitly determine the goals either. As for the use context, the only predefined data were the use cases that partially described the intended functionality of MMS and the type of mobile phones the application will be running on. End users and their social and physical environment are unknown.

The project did not get any permission to contact directly the end-users. The team's mere channel to understand users was through the written customer requirements about MMS. In the project lifecycle, the customer representative was the only live source that had the knowledge about end-users. He was a key person in the customer organization. It turned out that it was not possible to involve him in studying MMS usability. The user background information was never clear. Sources for analysing tasks and defining workflow logic were limited. The use cases of customer requirements, the knowledge of the business case in the project plan and the software requirements specification by the development team were the only material to study the functions and tasks of MMS. The criteria to measure the usability of incorporated "features and attributes" [ISO 9241-11, 1998, p. 9] of MMS were subject to study. Because of all these aspects, the MMS usability requirements specification was incomplete.

However, Thomas [1996] cites that requirements analysis is an especially important factor for evaluating the complex groupware applications. Andriessen [1996] also proposes interleaving the requirement analysis with the evaluation for groupware applications. He explains that the interaction processes including communication and group-oriented processes are the evaluation foci for groupware applications. Hence, modelling the relevant requirements are prerequisites to ensure successful evaluation of groupware applications. Nevertheless, when the user information is an unknown variable, the specification formulation of the product in terms of effectiveness, efficiency and satisfaction is unlikely to be possible.

The existing guidelines [ISO 9241-11, 1998; ISO 13407, 1999] mainly present the format and content required for usability requirements specification. There is little literature on how to elicit and formulate usability requirements for particular software applications in actual development situations [Jokela et al., 2006; p. 354].

To complicate the case, the MMS development team members were beginners of Symbian C++ programming. They did not have previous experience in mobile computing. This indicated that fast prototyping of an interactive MMS was unlikely for usability evaluation purposes. The project did not plan to build up any operational prototype before the implementation of MMS either. The only functional MMS would be the final product to be delivered to the customer in the last phase of the project. It meant that most of the usability activities had to take place without any operational MMS system.

Additionally, real end users were not possible to be involved in any usability activity, which might demise the reliability and validity of the evaluation results. Last but not least, the tight schedule and lack of financial resources in developing MMS turned out to be another problematic issue in deploying usability evaluation. Therefore some of the otherwise suitable usability methods were not practical for the project.

3.3 Summary

To sum up, there are three main types of challenges in the usability assessments for the MMS application under construction. One of them is related with the immaturity of the evaluation techniques for mobile collaborative applications. Another is caused by the problems in modelling usability requirements. The third is concerned with the project environment constraints.

The lack of usability goals, unclear target user population and undefined social context of the application inspired me to study the relevant literature about similar applications. I hoped to learn from literature more about the users and other use context requirements of similar applications as MMS. The uncertainty about the usability evaluation methods led me to examine more about how others have studied the usability of mobile collaborative applications. I present the results of my literature study in Chapter 4.

4 Related work

In this chapter, I will present a literature survey about usability studies carried out so far on mobile and groupware applications respectively as there is little direct research about mobile groupware applications. I will also take a close look at the usability features of other automated meeting schedulers in particular as MMS is a mobile meeting scheduler.

Most of the usability studies about mobile devices and applications [Ketola and Röykkee, 2001; Po, 2003] have taken examples only from single user interfaces. Conversely, research about groupware usability [Neale et al., 2004; Grundy et al., 2002; Baker et al., 2002] focuses on analyzing applications designed for desktop and laptop computers. Even though Tang et al. [2001] explored awareness issues that facilitate mobile groupware communication, they did not mention about possible usability evaluation methods in the field.

The emphasis of my survey is how researchers have studied the usability of both mobile and groupware applications in the context of project development. The foci will include the usability attributes and study methods of mobile applications, automated meeting schedulers and groupware applications in general. Additionally, the ease and effectiveness of applying these methods in the practice of a particular project development environment will be addressed. The purpose of the survey is to analyze if these previous studies have any implications on defining the usability requirements of MMS and paving the ways to approach the usability evaluation of MMS and other mobile groupware applications.

4.1 Usability studies of mobile phones and applications

Mobile phones have become indispensable in people's routine [Grundy et al., 2002]. Mobile applications such as mobile web browsers, mobile email systems, mobile web applications, mobile commerce, mobile cameras and games have added value in mobile phones and mobile operation services. Usability and user-friendliness are important to help mobile phones and their applications gain their popularity [Duh et al., 2006]. A good design is one of the core issues that promote sales. Usability considerations are the starting point for a good design. Mobile phones and applications with good usability can reduce mental and physical stress, leverage learning load, and avoid errors in operations [Hiltunen et al., 2002; Ramsay and Huntington, 2001].

Studies of usability attributes and evaluation methods on mobile phones and applications are emerging to be important for developing the mobile phone industry. Among many researchers, Kristoffersen and Ljunberg [1999], Ham et al. [2006], Wright et al. [2005] and Halpert [2005] have contributed their efforts in the area. I will present some of the work done so far in the following subsections.

4.1.1 Mobile use context

Kristoffersen and Ljunberg [1999] made their empirical studies of mobile work in two settings—telecommunication service engineers and maritime consulting staffs. They found that the context in which these people use computers differs very much from the office. Figure 9 is an example of a mobile work context.

Figure 9. A service engineer at a post [Kristoffersen and Ljunberg, 1999].

In Figure 9, the service engineer is working high up a post. His hands are occupied with tools and materials. He might need one hand to keep himself in balance from time to time. If he needs to look at the screen of his mobile device closely for input and output data, he might need to use both hands. This seems to be impractical.

Kristoffersen and Ljunberg disclosed that the work context of mobile and traditional office environment is different from each other. They summarized the mobile work context as the followings.

- Mobile computer operation is a subtask as opposed to the office environment where computer handling is the main task for users.
- Users' hands are often occupied to handle physical objects. However, in the traditional office environments, users can place their hands freely and safely on keyboards.
- Users may be engaged in tasks demanding high level of visual attention. They would not have much attention for the screen of a mobile device. In office environment, users' attentions are directed largely by computers or mobile devices.
- Users may be highly mobile during the task, as opposed to in the office, where moving around and operating tasks rarely occur at the same time.

It seems that the mobile work context described by Kristoffersen and Ljunberg generalizes the use context of mobile applications. The content might work as a good reference to define MMS use context. The content will be a good base to create MMS user interaction scenarios [Rosson and Carroll, 2002] as well. Consequently, the use context and the user interaction scenarios will reflect the user task environment. In turn, the use context based scenarios will exemplify the usability requirements of MMS in an authentic way.

Wright et al. [2005] used the traditional Heuristic Evaluation method [Nielsen, 1994] to study the usability requirements of a mobile fax device—MoFax. The target user group of MoFax is workers from the construction industry. Figure 10 gives a glimpse of the basic functionalities of MoFax. Users need to log into the application before they can see the list of messages as shown in the screenshot. The application enables users to send fax messages to MoFax users or to fax machines. It supports users to receive, reply, forward, find and delete fax messages as well.

Figure 10. MoFax main menu [Wright et al., 2005].

Wright et al. evaluated the operational MoFax application on mobile devices together with related documentations in the late phase of development. They found usability problems in menu operation, fax messages viewing, program navigation, undo/error correction and Login. They further analyzed the causes of the problems.

Their conclusion was that MoFax should be redesigned as the present interface did not support users in completing their tasks. In the new design, they applied a reduced version of the user-centered design method [Constantine and Lockwood, 1999]. They first defined a navigation map to contain three interaction contexts—a primary interaction context, an interaction context in viewing fax messages and an interaction context for editing and sending fax messages. For each interaction context, they built up identical content models. Based on the navigation map and content models, they established the menus and program navigation. A re-evaluation of the mock-up proved that the usability of the redesigned MoFax user interface had improved a lot.

The MoFax case study implies that UI view arrangement and information logic flow have great impact on the usability of mobile applications. Mobile devices tend to have small screens. Therefore, the logically simplified content organization and user interface with clear status indication are important to improve the usability of mobile applications. The experience of using Heuristic Evaluation rules in the evaluation indicates that the inspection techniques initially developed for desktop applications work to identify certain usability problems of mobile applications. These problems are related with menu organization, window views and navigation path. However, Wright et al. did not evaluate MoFax in mobile use context. They did not discuss the validity of the evaluation results either.

Ketola and Röykkee [2001] affirm that the user interface interaction elements affect the usability of mobile phones. They categorize mobile user interface elements into input, display, audio and voices, ergonomics, detachable parts, communication method and applications. Other interaction elements include external interface and service interface. The external interface contains user support, accessories, and supporting software while the service interface refers to the service provider's services. They all contribute to the usability of mobile phones and applications.

Kiljander [2004] further divides the usability concerns of mobile interaction in three aspects: logical user interface (LUI), graphical user interface (GUI) and physical user interface (PUI). LUI concerns information contents and layout for task handling. Menu structure and navigation structure are examples of LUI. GUI is related with the graphical or visual elements representing the information users need to carry out tasks. Icons and font are example elements of GUI. PUI refers to physical elements such as keypad and microphone. They support users to carry out physical operations in order to complete tasks.

In studying the usability impact factors of mobile phones, Ham et al. [2006] pointed out that the main constraints of mobile interfaces are small screen to display a lot of information simultaneously, multi-functions on physical buttons and limited processing power and memory. Consequently, critical usability issues include information organization and navigation as well as logical mapping of different keys in different modes for specific functions.

Overall, the past studies have found that the usability aspects influencing the interaction between users and mobile devices and applications include:

- dynamic use context
- need for visual attention
- hand manipulations
- cognitive load
- information organization
- navigation

- logical mapping of different keys in different modes.

These aspects seem relevant for MMS in respect of mobile use context and information arrangement. They could be part of the reference sources in specifying MMS usability requirements.

However, the past studies seldom examine the interactive communication between users of different roles mediated by mobile applications. This might be due to the reason that most of the example applications in these studies are for single users. The study results contribute mainly to the design and evaluation of mobile devices and single-user mobile applications. Directly applying the results in studying the mobile groupware applications such as MMS might not be considerate. For instance, in the case of MMS, the features listed above do not address the usability aspect of interactions between organizers, optional attendees and required attendees mediated by the application.

4.1.2 Running usability tests in the field or laboratory

Kjeldskov and Stage [2004] conducted a survey about techniques to evaluate the usability of mobile devices and applications. They summarize that the traditionally established usability evaluation methods fail to reveal key usability problems pertaining to mobile devices and applications. Therefore, many researchers have brought up new techniques and methods to evaluate the usability of mobile applications. At the same time, arguments about the efficiency and effectiveness of different evaluation techniques also arise [Duh et al., 2006; Kaikkonen et al., 2005; Halpert, 2005]. One of the controversies is if the laboratory test is sufficient to evaluate the usability of mobile applications in comparison to field tests.

Duh et al. [2006] carried out the same test tasks in the field and in the laboratory. The test tasks were all scenario based. They included making and answering phone calls, sending and replying to short text messages, creating multi-media messages and visiting mobile internet. The mobile phone used was Nokia 6220.

In the laboratory setting, they linked two digital video cameras. One camera was to capture the screen of the mobile phone interface while the other was for monitoring and recording the facial expression of test participants. The quad processor coupled the two separately captured video images to be side by side in order to make the test analysis easier. During the laboratory test, participants were sitting in the lab.

In the field test setting, a digital video camera was attached to the mobile phone in order to capture the phone screen. One test moderator used another digital camera to record the test participants' facial expressions. Another test moderator assistant was around to control the recording sessions accordingly. During the field test, participants were moving around according to scenarios.

The purpose of the study was to compare the results of usability tests conducted in the field and laboratory. The comparison revealed that the field tests identified more types of usability problems which were more critical to the usability of the mobile devices. The laboratory test could not spot the problems related with mobility.

However, Duh et al. did not seem to have taken into account how the performance of test participants might be affected by how the task scenarios were understood. They also neglected to consider that the performance of the test participants might be demised by how the tasks were assigned.

In the laboratory test, test participants got to understand the task scenarios by reading the description sheet presented on paper in front of them while they were sitting in the peaceful laboratory. They preceded the tasks with their personal understandings of the scenarios. The understandings of scenarios might vary according to the personal experience of the participants.

Incidentally, in the field test, the test moderator held the slip of paper describing the task scenarios in front of the test participants for them to read while they were moving around in a public place. The test participants were expected to play roles and act according to the scenarios. The reading from a slip of paper held by another person might be awkward to some participants. Some other participants might feel uncomfortable or unnatural to act in roles in public while the test moderator observed and recorded them. Turning heads and noise from other pedestrians on the street might also distract the test participants' attention to perform the tasks. All these might hinder test participants from performing the actual test tasks, eventually generating unreliable test results.

Nielsen et al. [2006] did a similar study on a mobile barcode scanner in order to understand whether the laboratory test or the field test fits better to evaluate the usability of mobile systems. The scanner is for skilled workers to register their use of equipment, materials, mileage and time. It operates on a regular Sony Ericsson T68i mobile phone, with an AirClic barcode scanner attached. It uses GPRS for transmitting data. When users need to register some information, they need to scan the appropriate barcode with the scanner. They interact with the system through the keyboard of the mobile phone. Nielsen et al. arranged the settings of the laboratory test and the field test in identical ways. They attached a mini-camera to the mobile barcode system to capture the screen of the user interface during test sessions as shown in Figure 11. They used a microphone to record the sound.

Figure 11. Mini-camera attached to mobile barcode system [Nielsen et al., 2006].

The analysis of the test results supported the findings of Duh et al. [2006]. Nielsen et al. confirmed that the field test makes it possible to locate usability problems related with cognitive load and interaction style in the mobile condition. Hence, they conclude that it is worthwhile to conduct the field based usability study for mobile systems even though it might mean a complex event.

Conversely, Kaikkonen et al. [2005] adhere that a laboratory usability test is sufficient when studying issues about user interface and navigation of mobile applications. The application they studied was Mobile Wire. It is for file transferring between computers and the mobile terminals. The field test happened in the Helsinki office district while the laboratory test took place in a typical usability test environment. In the laboratory test, they used three different cameras and microphones to record the screen and keyboard of the mobile handset, the face and overall picture of test participants concurrently. The test participants used the think-aloud protocol. In the field test, test participants wore special equipment to allow the recording of text data while they were moving around as shown in Figure 12.

Figure 12. Mobile application field test equipment [Kaikkonen et al., 2005].

The test results showed that there was no statistically significant difference in the number and severity of problems found in the tests. The individual task performing times did not differ significantly from each other either. In contrast, the total time spent for arranging the field test was two times as long as for the laboratory test. This was because it took time to travel to the test locations in the field. The study also found that application logic problems occurred more often in the field test than in the laboratory test. This might be caused by the fact that the field environment is more distracting. As an example, the photo on the right in Figure 12 shows that a test participant had to stop himself next to some windows in a shopping mall in order to seek for a peaceful place to concentrate on the demanding tasks.

The test settings for all participants are reported to be the same. The test participants in both field and laboratory tests are also reported to have similar experience with mobile phones. These increase the validity of the test results.

Kaikkonen et al. concluded that the field test does not have added value in evaluating the usability of mobile applications or devices. In fact, they point out that the laboratory test is more economic in supporting user-centered design in the context of a real product development. Their conclusions did not exclude that field test might be meaningful in studying user behaviors in public for executing tasks on a mobile phone.

The study of Kaikkonen et al. suggested also that how to evaluate mobile applications depends on what is the goal of the evaluation. If navigation and user interface details are the main issues to be evaluated, the laboratory test is enough.

As a matter of fact, all the studies discussed in Subsection 4.1.2 share the same methodology. They conducted usability tests in both field and laboratory environments for the same mobile devices and applications. Their test settings and analysis equipments were identical as well. Their purposes were to compare the test results regarding task performance time, problem categories and severities under the field and lab testing environments. Nevertheless, they did not mention their usability evaluation objectives in respect to the product specific usability requirements or project development environment. None of the studies set out to analyze or define the usability requirements of the product they evaluated. They did not seem to have designed their test tasks according to the usability requirements of their devices or applications either. This indicates that the validity of the test tasks and test results in these studies remains as an open question.

Additionally, all these studies deal with single-user mobile devices and applications. Not all the research results could apply to the study of mobile collaborative applications. First of all, the test tasks of mobile collaborative applications would need to consider the multi-user communication requirement. Secondly, evaluating mobile collaborative applications might need to have more than just one test participant in one test session.

4.1.3 Other usability methods for mobile applications

In parallel to the methodological debate addressing issues of mobile usability testing in the laboratory or in the field, some other researchers [Po et al., 2004; Pinelle et al., 2003] develop other methods to assess the usability of mobile applications. These methods include inspection based evaluations and ethnographic interviews. According to Po et al. and Pinelle et al., these methods are more cost effective, fast and practical to justify the usability problems of mobile applications in comparison to the usability test. Moreover, these methods are also easier for practitioners to learn and apply than laboratory or field test.

Po et al. [2004] developed Heuristic Walkthrough (HW) to evaluate mobile devices by adding scenarios of use into Heuristic Evaluation (HE) [Nielsen, 1994]. They also proposed Contextual Walkthrough (CW) to conduct heuristic walkthrough in the field.

The study of Po et al. had three experiments: HE in the laboratory, HW in the laboratory and CW in the field. In all the three experiments, evaluators worked on the same kind of device—Casio Cassiopeia E-10 pocket PC. Before an individual evaluation session, each evaluator got the chance to become familiar with the device. In addition, evaluators got a training session about Nielsen's ten heuristics before each experiment started. In the training session, evaluators were encouraged to ask questions in order to ensure that they understand the meanings of the heuristics. During the experiment, Po et al. asked evaluators to comment about the evaluation techniques they were practicing. Upon completing each evaluation, the evaluators identified the usability problems and rated them according to the five-scale ranking system suggested by Nielsen [1993].

HW intends to bring the mobile use context into HE by creating scenarios reflecting the contextual situation where evaluators needed to go through targeted tasks. Figure 13 shows a typical scenario used in the HW experiment.

Creating a New Appointment

Michael is a lecturer at the University of Melbourne. He teaches Financial Accounting and he has to record a lot of appointments and meetings to attend throughout the semester. As a result, Michael has bought a new Pocket PC in order to better organize his busy schedule.

Michael is currently in the canteen having lunch with his colleagues. Suddenly, a student approaches him and says that she has problems understanding the Accounting lectures. Since he is having lunch, he decides to have a discussion with the student another time. Therefore, Michael quickly reaches for his new Pocket PC and grabs the pointer (provided with the system) to key in data. He selects the appointment menu and enters the data and sets an alarm to remind him of the appointment when it is due. Once he finishes entering the details into the Pocket PC, he continues chatting with his colleagues.

Figure 13. Sample scenario of Heuristic Walkthrough method [Po et al., 2004].

This scenario is to support the task of creating a new appointment by using Casio Cassiopeia E-10 pocket PC.

The HW experiment took place in the laboratory environment for ease of arranging facilities and moderating usability evaluators. The scenario based tasks in the experiment enabled evaluators to draw on their own experiences and knowledge about the activity context. In fact, the scenarios directed evaluators to check major functions of Casio Cassiopeia E-10 pocket PC. Nielsen's [1994] ten heuristics mentioned in Section 2.3.3 were available to evaluators during their evaluation in order to guarantee their consistency in understanding the heuristics.

The CW experiment carried out heuristic walkthrough in a field environment. The places were realistic in terms of the scenario descriptions. Evaluators moved around in elevators and cafeterias when evaluating the device in accordance with the scenarios they had. As a result, evaluators were exposed to ambient noise and movement of other people during the evaluation as seen in Figure 14.

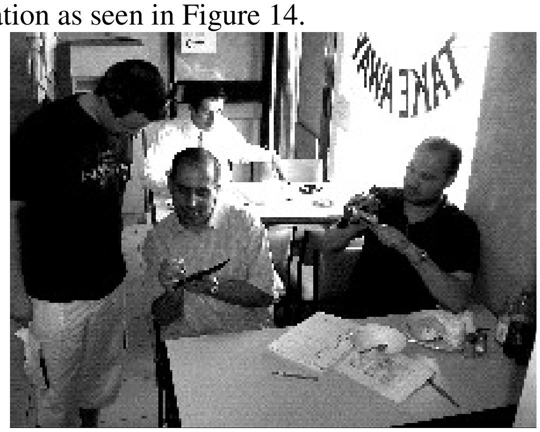

Figure 14. Contextual walkthrough in the field [Po et al., 2004].

Po et al. found that HW and CW can enable evaluators to find more usability problems of higher severity in comparison to HE. The usability problems identified by HW and CW were more related with problems that occurred in mobile context which HE failed to address. In contrast, in the HE experiment evaluators turned out to examine the device in an abstract way. They found only minor and cosmetic usability problems from the device. The descriptions of the findings were in terms of technology without much specific design reference.

In comparing CW with HW, Po et al. noticed that CW enabled evaluators to recognize problematic issues concerning input from the keyboard, lightings in the environment and the processing speed of the device. This was due to the CW evaluators moving around in an environment with changeable lighting. The field environment was more realistic than the laboratory environment. However, the evaluation results between HW and CW did not have much difference concerning the percentage of major and catastrophic usability problems identified. Secondly, CW likely consumes more time than HE or HW.

Po et al. seem to have fulfilled their research target at exploring if enriching heuristic evaluation by using scenarios or conducting it in the field helps to identify more usability problems, or problems of greater severity. However, they used a PDA device as their study example. The research did not cover the applicability of HW or CW to the usability evaluation of mobile collaborative applications. On the other hand, the evaluation objective of the experiments was not to evaluate a mobile device or application in terms of its usability goals. The research did not discuss either much about the correlation between the costs and results of the methods in a particular project based product development environment.

Not long later than the study of Po et al., Gallant [2006] introduced a combined method—“ethnography of communication approach” to evaluate the usability of mobile products. The method comprises of laboratory usability testing and profound ethnographic interviewing. During the laboratory testing, participants go through predefined test tasks using the think-aloud protocol [Dumas and Redish, 1999] while the test moderator asks them in-depth questions. Test tasks are defined to reflect major functions of the application under testing. The questions are related to how test participants would use the mobile product in their work activities. The interviewing enables test participants to describe their needs, and they tend to give ideas about how and why they would use the product.

The application Gallant studied was a customer relationship management (CRM) system. The target user group was salespeople. The evaluation was about two conceptual themes of the application, “mobile account management” and “Post-it-Notes”. Gallant found that the interview talk after the formal usability test enabled test participants to talk freely about their real life stories around the CRM by using their own vocabulary. The findings of the interviews provided designers with rich sources to create authentic scenarios and personas for development purposes. The vocabulary test participants used during the interviews helped designers to come up with user-friendly terms used in the software user interface.

The “ethnography of communication approach” seems to be effective in assessing certain design concepts and the user’s behaviour towards a mobile product in a laboratory environment. The approach is likely to support early stage user-centred design. However, this method relies on test participants’ verbal opinions to interpret the data observed during the laboratory testing. In some culture where people are not used to air their personal opinions in public, the approach might be problematic. The expertise of the interviewer might also affect the results of data collecting. Another issue is that Gallant only used the example of proof-of-concept test to explain the approach. The validation of the approach desires more investigation.

In all, the usability studies of mobile devices and applications examined so far target at identifying the usability aspects of the mobile devices and applications mentioned earlier. The exploration of different evaluation methods focuses on how to best identify usability problems in order to bring out mobile devices and applications of good usability. All the discussions are about if field test, laboratory test or inspection based method fits the best. However, researchers [Duh et al., 2006; Kaikkonen et al., 2005] have realized that more empirical studies are needed in order to validate the derived evaluation methods for mobile devices and applications. Moreover, the examples used in the studies were mostly related to single user interfaces. Few of the studies offered direct insight into the evaluation of mobile groupware applications to support user-centred design.

4.2 Groupware usability studies

As mentioned before, MMS is a mobile groupware application. In essence, it is a groupware-based automated meeting scheduler for mobile phones. The application enables meeting organizers to make automatic inquiries about timeslots' availability to the people in their buddy list through the calendar AS. The finally agreed and accepted timeslots for meetings will be reserved automatically as well in the mobile phone calendar of the invited participants through the AS. The survey in Section 4.1 shows the usability requirements and evaluation methods for mobile devices and applications in general. In addition, in this section I will look into the functionality requirements and usability evaluation methods for automated meeting schedulers.

The purpose is to generalize the users' needs for automated meeting schedulers. Additionally, it might help to answer one of my research questions of the thesis–how to evaluate mobile collaborative applications.

4.2.1 Functionality requirements for automated meeting schedulers

Grudin [1994] pointed out that automatic meeting scheduling has been a popular feature accompanying different types of electronic calendar systems. Meeting scheduling is a complex task involving many dimensions. Over the years, some researchers [Kincaid et al., 1985; Beard et al., 1990; Brzozowski et al., 2006] have made their efforts to study the usability requirements of automated meeting schedulers in order to make them useful to users.

As early as 1985, Kincaid et al. [1985] conducted an extensive survey to office workers in order to make assessment of the user needs for scheduling meetings. Their survey results proposed that a meeting scheduler should accommodate certain features before users could find the application useful in the real world. These features include the following requirements.

- Users should be allowed to specify who is to attend (not necessarily themselves) the meeting.
- The specification of a meeting's time range should be allowed.
- All possible meeting times should be presented, and the user should be permitted to select the most appropriate time.
- A warning should be given when conflicts arise, but conflicts should not prevent a meeting request from being sent.
- Each participant should be notified of the tentative meeting, and the system should request a response from each. The participants, however, should be allowed the option of postponing their reply to a later time.
- The person setting up the meeting should be allowed to automatically cancel or confirm the meeting, with a notification sent to all participants.
- It should be possible to book resources along with meetings.

Beard et al. [1990] made a similar empirical study with a group of academic staff and students about the user requirements for the meeting scheduling systems. Their results are in line with the features listed in the study of Kincaid et al. Additionally, they observed that users tended to prefer priority-based timeslots. Users also like to have access to scheduling reasoning.

The observations made by Beard et al. [1990] explained the phenomena Higa and Sivakumar [1996] encountered. In comparing an automated group scheduler with a face-to-face and email coordination system, Higa and Sivakumar found that the automatically selected times resulted in fewer scheduling conflicts. However, users turned out to be less satisfied with the time selection.

Brzozowski et al. [2006] believed that it was because the automated group scheduler did not let users to know about the reason for the time selection. The scheduler simply informed users with its answer. Dourish [2001] supplemented that scheduling a meeting is a social interaction in essence. The scheduler should let users to be in control of their interaction as much as possible. Accordingly, Brozozowski et al. proposed a system of preference-based group scheduling in order to overcome the problem.

Palen's [1999] research about social, individual and technological issues for groupware calendar systems indicates that users make use of meeting schedulers in conjunction with calendaring systems. This suggests that the use of meeting scheduler applications should integrate with users' personal calendaring systems. Otherwise, the meeting scheduler will not support users to accomplish their tasks realistically.

In brief, the past studies about automated meeting schedulers have shed light on users' requirements for the functionalities of such applications. These studies have elicited the requirements on basis of general users of such applications—office workers, academic professionals and students. The elicited requirements are beneficial in designing and evaluating the functions of similar systems. However, these studies have not addressed the issues of how to convert the suggested functionalities into user interfaces so that users can learn and use the applications to complete their tasks at ease.

4.2.2 Inspection methods for groupware applications

In this subsection and the next one, I will investigate how other researchers have evaluated groupware usability so far. I will also check how emerging technology could benefit the research on groupware usability. My target is to gain better understanding on how to carry out MMS usability assessment to support user-centred design.

Baker et al. [2001; 2002] developed "*Groupware Heuristics*" to inspect the groupware usability by applying the theory of *mechanics of collaboration* [Gutwin and Greenberg, 2000] and Nielsen's HE methodology [Nielsen, 1994]. The mechanics of collaboration are basic activities of shared work—*teamwork* that group members must perform in order to get a task done collaboratively. The mechanics provide an overview of the work. They break down collaborations into specific actions that evaluators can assess one at a time. The following list is a summary of these mechanics.

- Explicit communication: intentional provision of information, either through speech, text, or gesture.
- Monitoring: gathering information given off by others through consequential communication or feed through.
- Coordination: synchronizing actions and managing access to shared resources.
- Planning: division of labor, reserving areas of the workspace for future use, or plotting courses of action.
- Assistance: provision of help to one another, either upon request or opportunistically.
- Protection: actions taken to prevent change to or deletion of a person's existing artifacts and work.

In conjunction with the mechanics, Baker et al. [2002] produced eight groupware heuristics inspired by Nielsen's HE. The groupware heuristics are for inspecting the groupware specific usability. They are as follows.

1. Provide the means for intentional and appropriate verbal communication.
2. Provide the means for intentional and appropriate gesture communication.
3. Provide consequential communication of shared artifacts.
4. Provide consequential communication of an individual embodiment.
5. Provide protection.
6. Manage the transitions between tightly and loosely-coupled collaboration.
7. Support people with the coordination of their actions.

8. Facilitate finding collaborators and establishing contact.

In order to illustrate that the heuristics are efficient in revealing groupware usability problems, Baker et al. [2002] experimented with Groove. It is a commercial groupware product providing a virtual space for real-time small group interactions. Participants create shared spaces to communicate and collaborate with each other. Baker et al. used two groups of inspectors to evaluate the usability of Groove. One group was students doing the evaluation as part of their graded course. They did not have much experience with usability evaluations. The other group consisted of teachers and researchers. They were experienced in usability work. Both groups of inspectors adopted the process similar to Nielsen's HE. They had considerable freedom on how they performed.

Figure 15 shows the result of the experiment. 3-5 evaluators can disclose 40-60% of the known teamwork problems. As a comparison, the figure presents that the same number of evaluators identified over 80% of usability problems on a single-user interface using Nielsen's heuristics [1994]. Hence, it seems that groupware heuristics are not as effective as the single-user ones. However, the interpretation of the heuristics might have affected the efficiency.

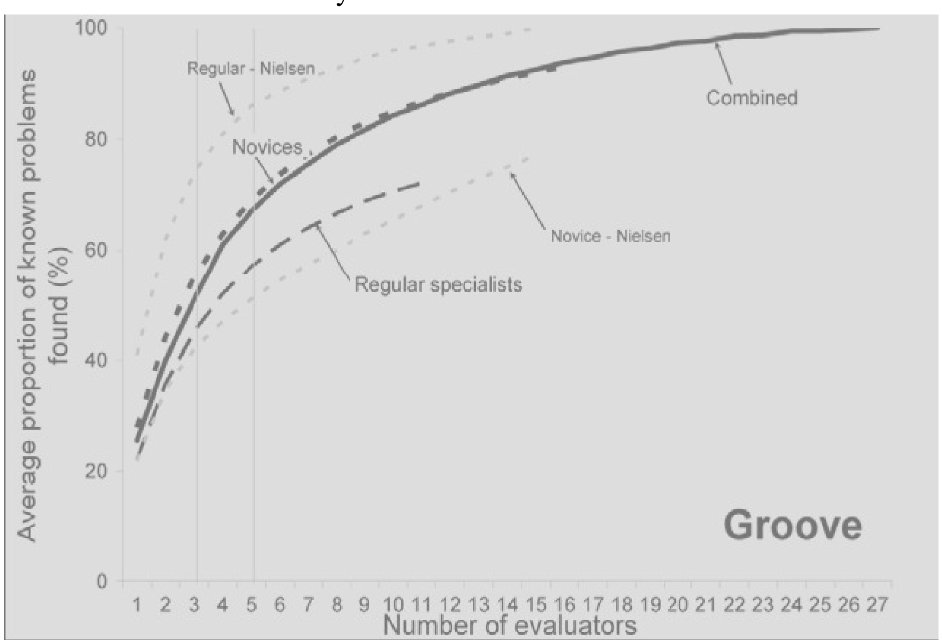

Figure 15. Percentage of problems found by each aggregate of inspectors [Baker et al., 2002].

It is surprising that the inexperienced evaluators found more problems than the experienced ones with groupware heuristics. The authors believe this is because the former ones were highly motivated as they performed the evaluations as a part of a graded course while the latter ones were not, as the only incentives were their willingness to assist in the research. On the other hand, the phenomenon denotes that it is easy to learn to use groupware heuristics in evaluating groupware applications. When working with Nielsen's heuristics, the evaluators' experience makes a big difference in the inspection results. Evaluators with less experience will find fewer usability problems than the ones with more practice. However, working with groupware heuristics, even beginners can justify more usability problems than experienced ones. This should be an advantage with groupware heuristics.

After all, the case study of Groove did show that the groupware heuristics are cost effective for identifying teamwork-oriented usability problems related to real-time—synchronous collaboration. The method is a discount usability inspection method. It is also easy to adopt. However, the study did not report what hinders the heuristics to uncover more usability problems. It overlooked to analyze what types of usability problems the technique fails to detect. It did not discuss either if the method applies effectively in evaluating the usability of asynchronous groupware applications.

While Baker et al. endeavoured to make the groupware heuristics a methodology to evaluate groupware usability, Pinelle and Gutwin [2002] proposed that groupware usability evaluation will be more effective by adding context into the discount usability evaluation methods. Hence, they developed the *groupware walkthrough* [Pinelle and Gutwin, 2002].

The method has two components—a group task model and a walkthrough process. Modelling a group task is to decompose the real-world group collaboration into specific actions that evaluators can assess one at a time on the basis of predetermined scenario specifications. Field observation [Beyer and Holtzblatt, 1998; Garfinkel, 1967] is a tool to collect real-world data for compiling scenarios. The scenario specifications structurally describe activities and circumstances in which users carry out their specific tasks in the real world. The specifications also include clear information about users of different roles. Consequently, the specifications guide evaluators to understand the users and realistic circumstances of the tasks when performing the walkthrough which has a six-step process. For each task, evaluators should

- check the users' attempt in carrying out alternate subtasks,
- examine how users conduct each subtask, and
- record the problems that occur.

After going through each task, evaluators are advised to review

- if the tasks are performed effectively,
- efficiently, and
- satisfactorily.

Pinelle and Gutwin illustrated the method by presenting their study about the usability of a home care system user interface. The system enables health workers of different roles to work together and provide mutual services to patients in their homes. These workers include nurses, case managers and therapists. These people seldom have a chance to meet face to face as they are often out of office or moving around in the hospital visiting patients. Figure 16 is an early prototype interface screenshot of such a system. The interface visualizes patient documents on a timeline of documentation date and the creator. Users can browse documents in the shared workspace while communicating with their colleagues via a chat window in the left pane of the interface.

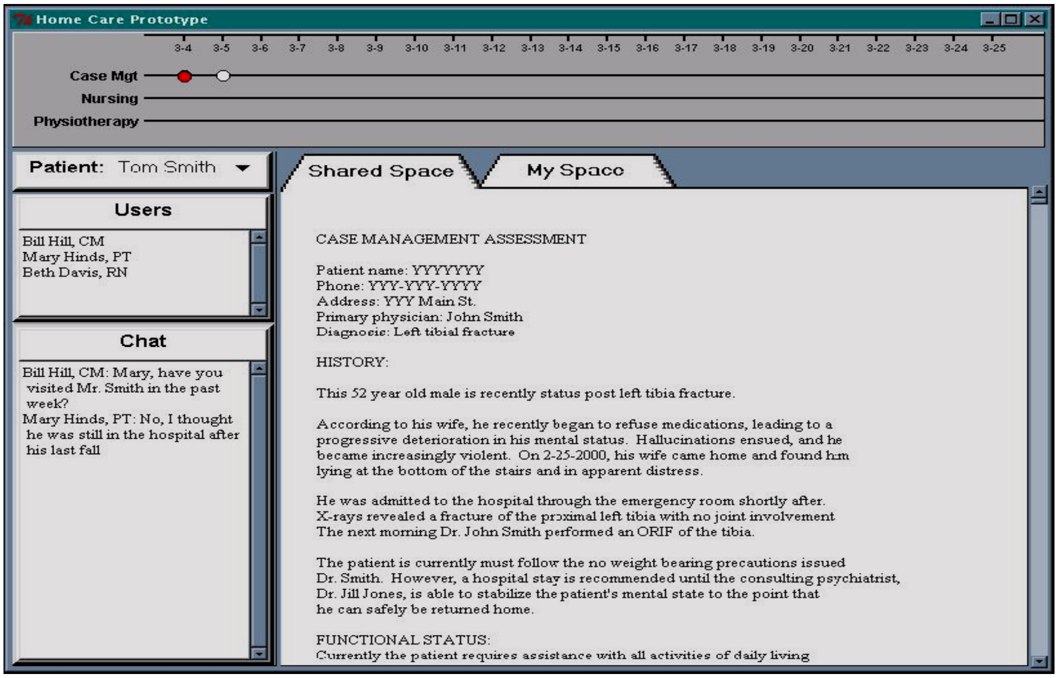

Figure 16. Home care system prototype interface [Pinelle and Gutwin, 2002].

In evaluating the home care prototype interface, Pinelle and Gutwin firstly collected user and use context data by interviewing workers while observing them working in the field. Then Pinelle and Gutwin modelled work scenarios in respect to roles of workers and tasks. After finalizing the scenario, they made the task analysis against respective scenarios.

One interesting example scenario Pinelle and Gutwin presented was for a nurse to determine the availability of a case manager in order to set up a meeting. The task analysis diagram of this scenario is elaborated in Figure 17. The nurse seems to have two alternatives in achieving the task of setting up a meeting with a case manager: either by directly asking the manager, or by spotting evidence about the manager's availability. After stepping through the specified tasks in the prototype, Pinelle and Gutwin found that the design did not provide enough information for users to determine the others' availability. They also noticed that the design was not supporting users to have direct communication about the meeting setup.

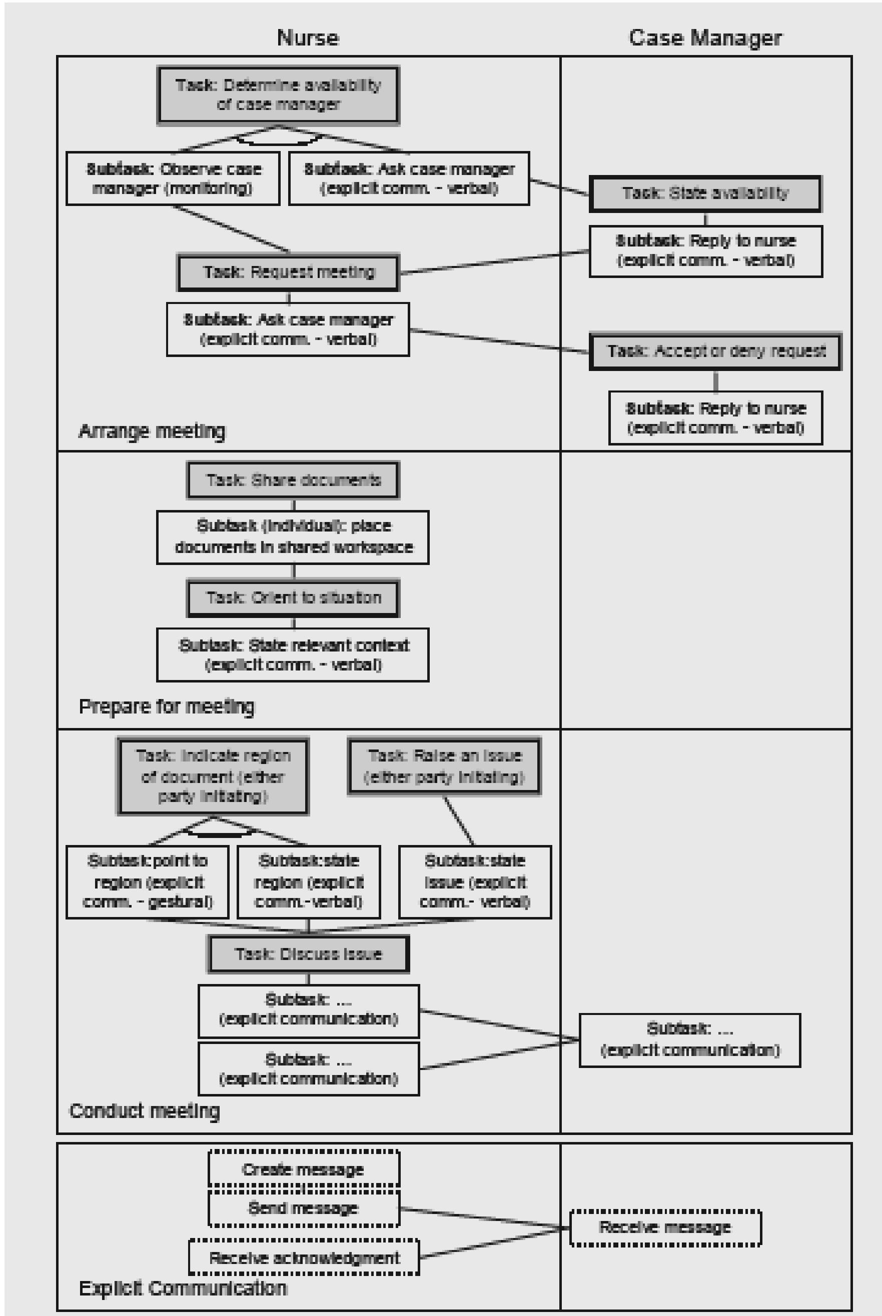

Figure 17. Scenario task analysis diagram of home care system [Pinelle and Gutwin, 2002].

In essence, the groupware walkthrough is a scenario based inspection technique. The scenario specifications are the actual guides conveying contextual information to examine the usability of groupware applications in terms of tasks. Therefore, the quality of the scenario specifications is one of the important determinants for a successful walkthrough.

However, the construction of scenario specification is based on the data collected from field observations and contextual interviews. Pinelle and Gutwin neglected to consider that methods of field observation [Kantner and Rusinsky, 1998; Anschuetz et al., 1998] might consume time, human resources and money. In practice, time, human resources and money are problematic in actual product development environments. In the case of the MMS project, simply there was no possibility to conduct any field observation.

Pinelle and Gutwin also overlooked that data interpretation is subjective to the selective memory bias of evaluators and interviewees [Wood, 1996; 1997] in field observations and interviews. Above all, the operation of the method seems to demand well-trained professionals of high competence who have experience and knowledge about field observation, interviewing, scenario extracting and groupware task analysis.

4.2.3 User-based evaluation methods and technologies

In contrast to the newly developed inspection techniques, some researchers proposed that groupware usability assessment should only be conducted by studying real collaborators in their actual contexts [Grudin, 1988; 1994; Orlikowski, 1992]. They argued that it is important to evaluate groupware over a period of time in order to address complex social and organizational issues. They criticised that the laboratory settings and inspection methods are not sufficient to address these concerns.

Nevertheless, after reviewing a large sample of papers concerning groupware evaluations, Pinelle and Gutwin [2000] found that only 35% of them applied user-based methods in field settings. Most of the papers dealt with synchronous applications for academic purpose. Few of them have taken background in any kind of product development project environment in work or organizational context. This might be because the technique of field studies consumes time and logistic arrangement efforts [Grudin, 1994].

As an example, Bowers [1994] used more than two years to study one groupware network for an organization in Britain. The author stayed in the organization for the study. He applied methods of field observations, contextual interviews, diaries and questionnaires with the aid of video taping. His study concern was the acceptance of the groupware tool to the users and the organization. He confessed that it was difficult in the end to characterize the needs of users as he had the huge amount of collected data which was not easy to analyse.

Sometimes even the arrangement of field settings might be problematic when there is no workable prototype available. Also when concepts of new products are top confidential as mentioned by Ketola et al. [2000], field studies are unlikely practical as well before the product is launched.

At the same time, it seems that most researchers [Orlikowski, 1992; Bowers, 1994] tended to use field studies to explore the impact groupware applications bring on to society and organizations. They mostly studied how groupware applications and systems might alter the behaviour of an organization and group of users. Researchers rarely adopted field studies to examine how user interface design affects the communication efficiency.

To address the potential problems field studies cause, Convertino et al. [2004] propose a simulated laboratory method to study collaborative awareness enabled by groupware applications. The idea of collaborative awareness was adopted from the theory of activity awareness. Activity awareness refers to people's capability in collecting and keeping "the big picture" about the ongoing overall collaboration while they are working together on long-term projects. Convertino et al. believe one of the major reasons why groupware applications fail is their lack of collaboration awareness.

Convertino et al.'s method includes the following factors

1. authentic tasks and collaborative situations
2. a confederate and
3. multiple collaborative sessions over time.

The authentic tasks and collaborative situations refer to collaborative scenarios developed from field observations. The confederate is a test participant working in pair with another participant to simulate the multi-user role of a groupware application. The multiple collaborative sessions over time enable the evaluation to include the detection about changes between collaborative sessions. The incorporations are to reproduce the live context of using groupware application in the laboratory setting. Convertino et al. argue that the data collected from the simulated laboratory testing is valid and reliable.

In comparison to field studies, the laboratory environment permits the test moderator to manipulate the test process. The laboratory test also allows the test moderator to collect more relevant and focused data in regard to the evaluation purposes. In other words, the amount of the data generated from the laboratory test will not be as much as those collected from the field studies. This will make the data analysis easier.

Convertino et al. illustrated the method by studying Groove. They recruited participants from students to complete four laboratory sessions. During the test sessions, participants were required to execute authentic tasks in collaborative situations modelled from real-world contexts.

All the participants had their confederates—other students who cooperated with the participants for laboratory tasks. The participants and their confederates were arranged in different rooms so that they could not see or hear each other. They were able to communicate with the experimenter via a microphone and a video camera. The experimenter had control over video and audio facilities to monitor and instruct each participant and confederate separately without disturbing the others. A Groove client was also available to the experimenter so that s/he could follow up the workspaces and intervene the test session when necessary. The study used different tools and methods to collect multiple data: the interaction data between participant and confederate through video cameras and a screen-capture tool; log about session changes and task assignment; notes taken by confederate; questionnaire and interview by end of the last sessions and the contextual inquiry interview during the test sessions.

Convertino et al. further compared the test findings with those from their previous field study about the same tasks. They found that the simulated laboratory method is valid and reliable for studying synchronous and asynchronous groupware usability in terms of activity awareness—examining when and how the collaborative activity breaks down. Unfortunately, they neglected to report about the time and efforts used for field observations before the laboratory testing. They did not mention the methodology and ease at analyzing the collected data either. Last but not least, they did not exemplify when to use this evaluation method in a groupware development project lifecycle in order to best support the user-centered design. It is not straightforward to justify how to transform the evaluation results into the design and development cycle.

It seems that most of the groupware evaluation techniques studied so far need to collect and analyze data from real life. This is in agreement with researchers' emphasis that groupware evaluation should occur in the context of actual use [Grudin, 1994; Orlikowski, 1992]. Some techniques require data from field observations and contextual interviews to compile scenarios and analyze tasks for further study at laboratory testing or walkthrough, whereas other techniques specify to make the complete study in the field setting. However, as mentioned by Orlikowski [1992] and Bowers [1994], the field methods involve a lot of labor and complicated arrangements in the field.

Finding economic and practical ways to collect and analyze field data seems to be an important part of a holistic approach to study groupware usability. To this end many researchers [Steves and Scholtz, 1999; Raento et al., 2007] attempt to seek aids from technologies.

As early as 1999, Steves and Scholtz reported to have developed a log data visualization tool to help assess the data collected during field studies. Their data collection techniques included the traditional direct observation, user interviews, diaries and email monitoring as well as the augmented log data. The application they studied was Teamwave Workspace which is to support collaborative work for automated gas-metal robotic welding in the manufacturing industry. They expected that the log data visualization tool will reduce the evaluation time required to identify and understand pertinent aspects and collaborative use patterns of the application. They foresaw that the tool will also produce relevant background data for conducting user interviews afterwards. In all, the tool should facilitate the groupware usability evaluation to adapt to the needs of user-centered design with less time consumed in comparison to the conventional field study techniques mentioned earlier. This log data visualization tool does seem to be inviting to be employed in the groupware usability studies. Unluckily, the authors did not depict how to use the tool at all. They did not inform the empirical experiment result with the tool either. All these make the adoption of the tool in other field studies less inviting.

Recently Raento et al. [2007] made innovative use of mobile technologies to explore a new way of conducting field studies. The traditional field study requires researchers and system evaluators to be on site observing the behaviour and activities of the target users. This causes the study to be labour intensive. The presence of researchers and evaluators might even distract the users' attention for performing the tasks they intended to do. The aftermath interview might not reflect the actual happenings as users and researchers might restructure their memories about what has happened.

To address these problems in the field study methods, Raento et al. [2007] explored to employ Smartphones for field observations and collecting log data. The authors explained that the Smartphone is a programmable mobile phone which is popular and costs around two hundred euros in developed countries. The phone can be programmed to be an automatic observation device for studying computer-mediated communication and social behaviours. Researchers can interact and follow up users remotely and unobtrusively. This allows labour- and cost-effective reach to previously inaccessible sources of data on social behaviour. In their paper, they illustrate the deployment of Smarthphones to record and study users' behaviours and use patterns of phone call making by running in the background ContextPhone—a software program to reveal clues of phone users' availability. Their experiment proved that it was cost effective to gather rich, high quality data with ContextPhone in Smartphones. The results pertained seem to be valid and reliable as well. They commented also that deploying Smartphones as a data collection tool was natural when the studied activity itself occurred at and through the phone.

However, the current Smartphones can only have connections with a limited number of sensors such as movement and proximity sensors. Situations when another mobile phone is not present make Smartphones impossible to detect any data. Additionally, the configuration of Smartphones for field study purpose requires a special technician familiar with mobile phone hardware, subscriptions, mobile data connection and transferring.

Hence, applying Smartphones in studying mobile groupware usability might seem to be attractive. Nevertheless, the limitations discussed might not promote the popularity of using the phones as a research tool among researchers and practitioners.

4.3 Summary

The range of the groupware usability studies reviewed so far in Sections 4.1 and 4.2 present researchers and practitioners with diverse perspectives to evaluate groupware applications supporting user-centred design. The common targets of these studies are to identify groupware usability requirements and explore effective evaluation techniques in order to identify groupware usability problems improving designs in general.

These studies show that contextual issues are among the key usability concerns of both mobile applications and automated meeting schedulers. This implies that MMS usability requirements include usability criteria for mobile applications and automated meeting schedulers. The implications supplement the MMS UI specification evaluation findings. As a result, the source to elicit MMS usability requirements is enriched.

The usability evaluation techniques examined in the literature can be summarized into inspection and user-based methods.

Most of the inspection techniques [Po et al., 2004; Pinelle and Gutwin, 2002; Baker et al., 2002] developed for mobile and groupware applications respectively are modifications derived from classic evaluation techniques intended for single-user desktop applications. Heuristic Evaluation [Nielsen, 1993; 1994] and Cognitive Walkthrough [Wharton et al., 1992; 1994] are examples of these classic techniques. The derived techniques aim to tailor the classic techniques to fit for identifying mobile or groupware specific usability problems in cost effective ways.

Meanwhile, the newly developed user-based techniques [Duh et al., 2006; Kaikkonen et al., 2005; Convertino et al., 2004] for mobile and groupware applications include laboratory test, field test and field study augmented by new technologies. The foci of these user-based techniques are about to bring the mobile and groupware specific contexts into the traditional user-based study methods. The scenarios are useful tools to help make these techniques work. Most of these techniques argue that laboratory tests with special arrangements according to the use requirements of applications are sufficient to identify relevant usability problems to support user-centred design. They all see that field tests and field studies can cause complex logistic arrangements. The manipulation of field related evaluations might not be practical in many cases in terms of time, human resources and money.

In order to overcome the negative results affected by field tests and other field study methods, some researchers [Raento, et al., 2007; Steves and Scholtz, 1999] have turned to new technologies for innovative solutions. They suggested that Smartphones might replace the labour intensive field observations and data log visualization tools might release researchers from overwhelming data analysis collected from field studies.

To sum up, the above mentioned evaluation techniques have their own merits and disadvantages in usability studies of mobile and groupware applications respectively. Some of them are cost effective but convey less design related information. On the other hand, some others are time consuming and generating lots of data which are difficult to interpret and cannot be generalized from. In addition, most of the example applications are designed for single-user use in desktop computer environments.

Consequently, the direct application of the teachings from the past studies to the usability evaluation of MMS might not help the design.

Hence, some researchers try to combine different techniques together introducing other kinds of derived user-based methods such as "ethnography of communication" advocated by Gallant [2006]. This method integrates interviews with laboratory user test in order to get the most efficient usability study results.

Indeed, all the past research presented in this chapter offer insights into approaching usability evaluations of mobile and groupware applications. These insights are either mobile or groupware applications oriented only. However, they are good departures to further develop evaluation techniques specific for mobile groupware applications such as MMS in order to support user-centred design.

5 Discussion

After the examination of the preliminary usability study of MMS in its project environment and the relevant literature survey, I will discuss in this chapter the aspects and methods to evaluate MMS and other mobile groupware applications at large. These aspects and methods are for sake of user-centred design of mobile groupware applications in concrete projects.

5.1 Evaluation aspects

On the basis of the guidance governed by ISO 9241-11 [1998] and ISO 13407 [1999], the exploration of MMS usability requirements implies that usability aspects of a mobile groupware application are many faceted. A generalization of these aspects includes

1) the logic flow and navigational structure of the application (logic flow)
2) necessary functionalities to support domain tasks of the application (functionalities)
3) the small screen design (small screen)
4) dynamic use context of mobile phones (the mobile context)
5) the user interface screen design from single-role user points of view (single-user UI)
6) the groupware user interface for teamwork tasks (groupware UI), and
7) the impacts on social behaviours (social impact).

Among these seven usability aspects, explicit logic flow and indicative navigational structure are portals for users to start learning and using any application. In a complex application of mobile groupware, it is even more fundamental for these portals to be as clear as possible matching the mind map of users. Otherwise users will turn down the application without even trying.

Furthermore, necessary functionalities in answer to users' tasks are application specific and crucial for a mobile groupware application to be useful. In the case of MMS which is an automated meeting scheduler, the necessary functionalities should enable users to specify meeting attendees and time. The users should be able to cancel or modify the meeting proposals with a notification sent to all participants. In addition, MMS should enable users to book meeting time automatically in participants' calendar systems based on their acceptance.

In addition, small screen design and mobile use context are usability aspects required for mobile applications in particular. At the same time, user friendly groupware UI supporting team tasks is as important as single-user UI facilitating individual tasks in contributing good usability for mobile groupware applications. Last but not least, the social impacts mobile groupware applications introduce are not trivial either in promoting such applications.

The seven usability aspects mentioned above are derived from the expert walkthrough of the MMS UI specifications, and the in-depth analysis of MMS use cases and the software requirements specification drafted by the project team. In addition, the extensive literature survey on the usability requirements for similar applications supplements the relevance of the seven aspects.

Theoretically, the listed usability aspects of mobile groupware applications are well grounded. Therefore, even though further empirical investigations might be needed to prove that these aspects are important to be evaluated, hopefully the concepts are of reference value for HCI practitioners and researchers in their future studies of mobile groupware applications. In addition, these concepts are intended to help leading the design and evaluation of user-centred mobile groupware applications to the right track from the very beginning of a software development lifecycle.

Additionally, the process of exploring the MMS usability aspects in the thesis has demonstrated a way to elicit the requirements in a particular software project development environment. Namely, the process is to start usability requirements elicitation from the available data in the project. Then, it is to analyse and search for the missing necessary information. The missing information could be extracted by applying economic tools such as use scenarios because of project constraints. These constraints might relate to tight budget, busy schedule and unavailability of end-users as seen in the case of MMS.

The MMS UI specification evaluation experiment indicated that the information flow of the application needs to be further analyzed and established before the interactions between users of different roles and the interconnections of all the functions are clear. The readily available use cases are too abstract for designers and developers to understand the concrete needs of the users. The experiment showed also that different expert evaluators had great disparity in understanding the usability of the application. One of the important reasons for the disparity was that evaluators had too little information about the user needs, use context and task requirements of MMS.

Therefore, after the experiment, I created the MMS user and system interaction scenarios shown in the Appendix on the basis of the use cases described in Chapter 2. In addition, literature survey in Chapter 4 about general usability requirements for mobile devices and automated meeting scheduler in general provided reference about the MMS user requirements. My primary target was to understand better the usability aspects of MMS and similar mobile groupware applications. The understanding will benefit the future usability evaluation and designing of such applications. Writing the MMS use scenarios was economic. However, as the scenarios are vivid and self-explanatory regarding user needs, use context and task requirements, they would have helped evaluators identify more critical usability problems in the MMS UI specification evaluation. These scenarios would have been good start for drafting MMS UI specification in the first place. They would have also benefitted UI designers to produce more user friendly user interface for MMS.

The usability requirements elicitation process has been logical and practical in the MMS project. The process might be possible for other projects of similar nature to borrow the idea in building up usability requirements for their applications in an economic way. In this sense, the process development enriches the instructions on creating usability requirements specification in ISO 9241-11 [1998]. In turn, the process supports the usability activity of identifying what aspects are important to be evaluated in order to support user-centred design of mobile groupware applications.

All in all, the identified usability aspects of mobile groupware applications will contribute as a general mind map for designers starting to develop such applications with good usability. In addition, these usability aspects will guide HCI researchers and practitioners to plan usability evaluations in the right track for mobile groupware applications. Moreover, the example of creating use scenarios to elicit the MMS usability requirements and yield design implications presents an economic user-centred design approach to mobile groupware applications.

5.2 Evaluation methods

The MMS preliminary usability study and literature survey on how to assess MMS usability in previous chapters suggest that the evaluation of mobile groupware applications is complex and has no previous example. This is in agreement with what Grudin [1988] asserts for the evaluation of groupware applications. Nevertheless, the experiment and the literature survey shed light into potentially useful methods in the evaluation of mobile groupware applications enhancing user-centred design.

In this section, I will further summarize the pros and cons of usability evaluation methods examined in light of the seven usability aspects for mobile groupware applications discussed in Section 5.1. The summary will be categorized on the basis of different types of evaluation methods, namely inspection-, user-based and combined methods respectively. The focus is to discuss how well these methods will evaluate mobile groupware applications such as MMS.

Inspection-based methods. *Heuristic Walkthrough* and *Contextual Walkthrough* of Po et al. [2004] concentrate on assessing single-user mobile applications. *Groupware Heuristics* advocated by Baker et al. [2001; 2002] and *Groupware Walkthrough* studied by Pinelle and Gutwin [2002] emphasize how to evaluate groupware applications in low-cost way. No user participant or working prototype is necessary when applying any of these four methods in usability evaluations. These methods are also intended to come up with cost effective evaluation results and design implications in the early stage of developing applications. While the competence of different evaluators plays an important role in identifying usability problems of software applications, some of these methods enable the identification of more usability aspects than others. Table 5 summarizes the possible findings of usability aspects enabled by these four methods respectively. The summary is based on the literature survey and the seven important usability aspects for mobile groupware applications.

USABILITY ASPECTS	**INSPECTION-BASED EVALUATION METHODS**			
	Heuristic Walkthrough	**Contextual Walkthrough**	**Groupware Heuristics**	**Groupware Walkthrough**
Logic flow	Unlikely	Unlikely	Unlikely	Likely
Functionalities	Unlikely	Unlikely	Unlikely	Likely
Small screen	Likely	Likely	Likely	Likely
Mobile context	Likely	Likely	Unlikely	Likely
Single-user UI	Likely	Likely	Likely	Likely
Groupware UI	Unlikely	Unlikely	Likely	Likely
Social impact	Unlikely	Unlikely	Unlikely	Unlikely

Table 5. Inspection-based methods for mobile groupware applications.

Heuristic Walkthrough and Contextual Walkthrough are based on Nielsen's [1994] ten heuristics which are originated to guide evaluators in assessing single-user applications. Hence, both Heuristic Walkthrough and Contextual Walkthrough likely help evaluators in identifying usability aspects related with single-user UI. Since these two methods bring use scenarios into evaluations, they also likely enable evaluators in identifying usability problems related with small screen and mobile context. Nevertheless, none of these methods is unlikely to reveal any problem caused by software logic flow, functionalities, groupware UI or social impact.

Groupware Heuristics and Groupware Walkthrough are designed in particular to evaluate the collaboration between users of different roles in addition to usability requirements of single-user applications. None of these methods has brought in any actual user or use environment into evaluating groupware applications. Therefore, both Groupware Heuristics and Groupware Walkthrough are useful at identifying usability problems of groupware UI, small screen and single-user UI. However, none of these methods likely reveals any social impact problem possibly caused by the software under evaluation. Furthermore, Groupware Heuristics does not analyze the group tasks nor use context of groupware applications. Hence, usability aspects of logic flow, functionalities and mobile context are unlikely to be spotted by this method. On the contrary, Groupware Walkthrough is intended to evaluate if group tasks are carried out logically and users of different roles are satisfied with groupware applications.

Groupware Walkthrough also brings use scenarios as references in the evaluations. Accordingly, usability problems in the aspects of mobile context, logic flow and functionalities are likely to be identified by Groupware Walkthrough as well.

User-based methods. User-based evaluation methods for mobile and groupware applications have also been under heated discussion in the literature surveyed. They include *Laboratory Test*, *Field Test*, *Simulated Laboratory Test* (Simulated) and the approach of *laboratory tests and ethnographic interviews* (Lab. test +interviews). Table 6 generalizes these methods in light of the seven usability aspects discussed.

USABILITY ASPECTS	**USER-BASED EVALUATION METHODS**			
	Laboratory Test	**Field Test**	**Simulated**	**Lab. test + interviews**
Logic flow	Likely	Likely	Likely	Unlikely
Functionalities	Likely	Likely	Likely	Likely
Small Screen	Likely	Likely	Likely	Likely
Mobile context	Unlikely	Likely	Likely	Likely
Single-user UI	Likely	Likely	Likely	Likely
Groupware UI	Unlikely	Unlikely	Likely	Unlikely
Social impact	Unlikely	Unlikely	Unlikely	Unlikely

Table 6. User-based methods for mobile groupware applications.

The Simulated method in Table 6 seems to be the most versatile among all other user based methods in identifying the most usability aspects pertaining to mobile groupware applications. This method enables the observation of user problems in logic flow and navigational structure, necessary functionalities, small screen design, dynamic mobile context issues, single-user UI for individual tasks and groupware UI supporting team tasks. Table 6 also displays that with a field test it is possible to reveal all other aspects the Simulated is up to except groupware UI. In comparison to field test, laboratory test reveals one usability aspect less. Apart from groupware UI, laboratory test fails to take into consideration the dynamic mobile context of mobile applications. However, no method in Table 6 is sufficient in detecting any social impact that a mobile groupware application might cause.

Theoretically speaking, in addition to the methods presented in Table 6, field study is another way to involve users into the usability study of groupware applications as pointed out by Grudin [1994]. Field studies might be suitable in collecting social impacts a mobile group might cause. However, discussions about field studies as alternatives to evaluate the usability of mobile groupware applications are limited in the thesis. Reasons for the limited discussions include complicated logistic arrangements, huge amount of data to be analysed, difficulty in generalizing the collected data and lots of time required in implementing the method. Even the modern technologies like log data visualisation tool [Steve and Scholtz, 1999] and Smartphone [Raento et al., 2007] are not proficient in levering labour from analysing data generated by field studies. Secondly, in the case of the MMS project, field study seems to be far from being realistic in its project environment.

5.3 Choosing methods

Tables 5 and 6 have shown the possible usability aspects each evaluation method for mobile groupware applications could identify. These aspects are important to be considered in setting evaluation objectives and screening relevant methods for studying the usability of mobile groupware applications. In addition, other crucial factors contributing to the selection of usability methods include the ease of data collection and analysis, availability of resources and the explicit of design implication.

The methods listed in Tables 5 and 6 include Heuristic Walkthrough, Contextual Walkthrough, Groupware Heuristics, Groupware Walkthrough, Laboratory Test, Field Test, Lab. Test + Ethnographic interviews and Simulated. Some of these methods are economic in resource requirements. They need only usability experts, early sketches and written scenarios. However, some other methods require more resources including test participants, operating prototypes and field environment. Regarding data collection and analysis, experts' individual reporting and group debriefing sessions are sufficient for some methods while interpretations about testers' performance record are mandatory for others. As to the new design ideas implied by usability evaluation results, some of these methods seem to be more productive than the others. Table 7 summarizes the pros and cons mentioned above in respect of each evaluation method listed in Tables 5 and 6 for the sake of enabling the selection of usability methods for mobile groupware applications.

METHODS	PROS AND CONS		
	Resources required	**Data collection and analysis**	**Design implication**
Heuristic Walkthrough	Early sketches, experts and scenarios	Experts' individual reports and group debriefing	Inexplicit
Contextual Walkthrough	The same as in Heuristic Walkthrough plus field context	The same as in Heuristic Walkthrough.	Inexplicit
Groupware Heuristics	Early sketches and experts	The same as in Heuristic Walkthrough.	Inexplicit
Groupware Walkthrough	The same as in Heuristic Walkthrough	The same as in Heuristic Walkthrough.	Explicit
Laboratory Test	Testers, experts, tasks, prototype, laboratory	Testers' performance record, experts' individual and group interpretations	Inexplicit
Field Test	Testers, experts, tasks, prototype and field	The same as in Laboratory Test	Inexplicit
Lab. Test + Ethnographic interviews	The same as in Laboratory Test	Testers' performance record, and experts' interview results	Explicit
Simulated	The same as in Laboratory Test	The same as in Laboratory Test	Inexplicit

Table 7. Choosing usability methods for mobile groupware applications.

As a matter of fact, the inspection-based Heuristic Walkthrough, Contextual Walkthrough, Groupware Walkthrough and Groupware Heuristics are expert evaluation methods. However, Groupware Heuristics is based on the expert's analysis about teamwork activities while the common theme of the rest methods is to scenarios on the basis of mobile groupware application use context in the usability evaluation. Consequently, the competence of experts involved is vital to the success of these methods. Secondly, the quality and the variety of scenarios will enrich the evaluation results. These methods are suitable in the early stages of mobile groupware software development since no working prototypes are necessary. However, most of these methods unlikely provide straightforward implications for designers to take along in improving user-centered design according to the important usability aspects mentioned earlier for mobile groupware applications. Nevertheless, Groupware Walkthrough is reported by Pinelle and Gutwin [2002] to produce intuitive design implications regarding groupware user interfaces, logic flow and navigational structures of groupware applications.

Laboratory Test, Field Test, Simulated and the approach of Laboratory Test and Ethnographic Interviews in Table 7 are user-based methods for mobile groupware applications. These methods require test participants, laboratory or field arrangement, predefined tasks and working prototypes. In order to make these methods usable in identifying more usability aspects of mobile groupware applications, both laboratory and field arrangements should be in line with authentic use context of such applications under evaluation. Test participant recruitments usually require both financial budget and human resources. Moreover, defining testing tasks deserves the competence of usability experts. Thus, these methods seem to be more expensive and time consuming in comparison to the expert methods. After all, the availability of working prototypes as one of the prerequisites suggests these user-based methods are apt at identifying usability issues of mobile groupware applications only in the later stages of software development. As far as the design implications are concerned, the approach of laboratory test and ethnographic interviews seems to enable the transferring of evaluation results into new design ideas better in comparison to other user-based methods illustrated in Table 7.

In the case of the MMS preliminary usability evaluation, there was no prototype yet available. The design was in early state with only software requirement specification and UI specification draft ready. There was no budget in recruiting test participants. However, students of Interactive Technology participating in the project work course might have been motivated to practice the evaluation. Hence, Groupware Walkthrough might have been the most suitable method. The MMS task analysis could have been based on the use cases provided by the customer and the usability requirements about automated meeting schedules extracted from the literature survey. The use scenarios in the Appendix could have been the sources to define scenario specifications for evaluating MMS.

6 Conclusion

The report of the MMS preliminary usability study shows that it was a challenge to evaluate the usability of MMS in order to support the user-centred design in the project lifecycle for the course of Project Work. The incomplete usability requirements of MMS motivated me to make a literature survey about previous studies on the general usability aspects of mobile groupware applications. The painstaking evaluation experience of the MMS UI specification triggered me to study empirical research on suitable evaluation techniques for mobile collaborative applications.

Based on the experiment of the MMS preliminary usability evaluation and the extensive literature survey on the usability studies of mobile groupware applications, I have generalized seven usability aspects for mobile groupware applications. These aspects include the logic flow, domain functionalities, the small screen design, mobile context, single UI, groupware UI and social impacts of mobile groupware applications. In addition, I have analysed further that the necessary functionalities of MMS should cover those of other automated meeting schedulers surveyed.

Furthermore, I have summarized the possible methods for evaluating the important usability aspects of mobile groupware applications in light of supporting user-centred design of such applications. These methods can be categorized into inspection- and user-based. On the basis of the summary, I also discussed the pros and cons of these methods in respect to their efficiency and suitability in identifying usability aspects of mobile groupware applications. As a result, it becomes clearer that Groupware Walkthrough might have been the most suitable method in the MMS preliminary usability study.

In conclusion, I recommend that the generalized seven usability aspects are considered in designing and evaluating mobile groupware applications of good usability. The summarized and discussed usability methods provide HCI practitioners and researchers possible tools to measure and support user-centred design of mobile groupware applications in different development status according to their project development environments. However, using Groupware Walkthrough to make another experimental study of MMS will be an interesting experiment in the future. The comparison of the future study results and those of the preliminary study will prove the efficiency of Groupware Walkthrough in identifying important usability problems of mobile groupware applications.

Moreover, I hope that the report of the MMS preliminary usability evaluation will attract other HCI researchers and practitioners in the field to be interested in further studying the usability aspects and techniques for mobile groupware applications.

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Appendix

MMS use scenarios

Scenario 1: Compiling and sending new meeting invitation to attendees

Lucy is a marketing department secretary in Avada Telecommunication Company. Lucy is currently traveling in the train from Tampere to Helsinki. She receives a short text message in her Nokia 6600 shown in Figure 1 from her boss Mike who is at a business planning meeting in New York. Mike instructs Lucy to arrange a meeting with all the sales managers to communicate about the marketing strategies of the first period of the year. Mike also expresses that it is good if the sales engineers could participate into the meeting as well. However, the presence of the sales engineers is not compulsory. The meeting will last around two hours. The meeting place is at the Tampere office. The meeting should be organized within one week. There are ten sales managers and eight sales engineers in the department. All of them are moving around the world for purpose of business.

After reading the message, Lucy closes the short text message application in her phone. She presses the button left next to the "Options" button to get the Menu content list view appearing to the screen. Then, she uses her left hand thumb to scroll and select the link in order to open MMS application.

Figure 1. Nokia 6600 mobile phone.

After she opens the MMS, the screen shows links to "Phonebook", "Request Buddy List", "Query for timeslot", "Compile invitation", "Update/Cancel invitation", "Send invitation", "Update invitation status" and "Coming meetings".

Lucy scrolls the black button in the middle of her phone to select the link of "Request Buddy List". After that, Lucy inputs her keywords "sales managers" by typing on the keyboard to get the detail name list of the sales managers. Lucy checks and clicks the names she wants to invite for the meeting. After that, the screen pops out links of “More buddy list”, “Query for timeslot”, “Send invitation”, “Save draft”, “”Cancel” and “Exit”.

Lucy selects “Query for timeslot” in order to check the availability of the managers for the meeting. In this function, she inputs the meeting time duration to be two hours and the date for the meeting is between “November 15 and November 21, 2007”. After a couple of minutes, she receives from the system the information about the suggested timeslots specified. Lucy selects the timeslot between 13:00 and 15:00 on July 17, 2007. The screen pops out links to “More Buddy List”, “ More Query to timeslot”,” Meeting theme”, “Meeting place”, “Meeting host”, “Send invitation”, “Save draft”, “Cancel” and “Exit”. Lucy selects “More Buddy List”. She requests the group address of sales engineers. She does not want to check the availability of the sales engineers as she thinks that they are not compulsory attendees. Instead, she clicks directly to edit the meeting theme, place and host. She is thinking of sending the invitation now.

At this moment, Lucy receives a phone call from Mike. Mike instructs her to prepare his traveling arrangements back to Tampere as soon as possible. After hanging up Mike’s call, Lucy feels that the travel arrangement is more urgent. Therefore, she processes Mike’s traveling issues with travel agency via her mobile phone. When all the phone calls are over, she notices that her mobile phone is flashing. She takes a close look at the screen and remembers that her meeting invitation is under processing. She needs to send the composed invitation. She selects the link of “Send invitation”.

In the function of “Send invitation”, Lucy suddenly recognizes that she has not yet checked the availability of Mike. She feels lucky that the “Send invitation” function has sub-functions of “View the newly composed invitation” and “Revise the invitation”. Lucy clicks the “Revise the invitation”. She makes a query to the AS about the availability of Mike and the sales managers at the same time. Finally, she decides the time to be between 8:00 and 10:00 on July 18, 2007. She double checks the invitation. Afterwards she clicks the “Send invitation” to all the compulsory and optional attendees.

However, Lucy is not sure if she needs to send the invitation again since she does not get any confirmation about her action from the system.

Scenario 2: Attendee receives new meeting invitation

John is one of the sales managers in Lucy’s sales department. He is one of the attendees Lucy invites for the marketing strategy communication meeting at between 8:00 and 10:00 on July 18, 2007.

He is driving his car on the highway in London from his hotel to a customer premise when his Nokia phone N95, as shown in Figure 2, says you have a meeting invitation from Lucy. John thinks that he would rather read the invitation when he arrives at the customer’s premise because the operation of mobile phone during driving is dangerous.

Figure 2. N95 mobile phone.

At the customer premise parking lot, John’s phone buzz reminds him that he has not yet handled the newly arrived meeting invitation. He parks the car and takes his mobile phone out from his briefcase. The screen shows a reminding message “Meeting invitation from Lucy”. He clicks the message link. He reads that the meeting time is at between 8:00 and 10:00 on July 18, 2007. The invitation message icon shows that he is a compulsory attendee. At this moment, he wants to check his own calendar if the time is OK with him. So, he tries to open the main menu of the mobile phone in order to open his calendar. It takes several minutes before his calendar opens. His calendar tells him that he is on the plane back to Finland during the time. He remembers now that he has not updated his calendar in the calendar application server for quite a period of time because he has been busy and traveling for about a month already. He goes back to the meeting invitation sent by Lucy and rejects the invitation. However, he feels that the meeting theme is important and he wants to meet his boss Mike. He thinks to propose a new meeting time to Lucy.

Unfortunately, MMS does not allow him to suggest a new time. The customer meeting is getting close. John has to suspend the issue of suggesting a new time to Lucy for the strategies communication with Mike. John thinks he might write a short text message to Lucy after the meeting with customer.

Scenario 3: Optional attendee receives new meeting invitation

Peter is a sales engineer of in the sales department. He is one of the optional attendees Lucy invites to the strategy communication meeting. When his Nokia 6680, as seen in Figure 3, receives the invitation, the phone gives his personalized tone to notify him when he is on one pole checking the base station transmitter.

Figure 3. Nokia 6680 mobile phone.

Peter wants to know the meeting theme and see if the meeting invitation is urgent or not. So, he holds his left hand on the pole while his left hand takes his Nokia 6680 out from his pocket. The screen reads that there is one meeting invitation from Lucy. He feels annoyed when he has to click the message link before he can read more about the invitation because of his physical position on the pole. It takes even more time when he wants to see the attendees' list. Finally, he finds that he is only an optional attendee for the meeting. He decides not to attend the meeting. He changes to hold the pole with his right hand leaving the left hand to operate the phone. He scrolls for the "Reject" button to inform his rejection of participating the meeting. At this moment, John notices that there is no network signal available.

Scenario 4: Organizer checks invitation response situation

Lucy gets off train and walks towards the taxi station when she opens the MMS to check the invitation response situation. She selects the link "View invitation response" from the main menu of the application by pressing the middle button. A list of the response situation appears to the screen. As she walks, it is not easy for her to read in detail the list. However, the summary of the list tells her that seven compulsory attendees and two optional attendees have accepted the invitation while one compulsory attendee has rejected the meeting and others have on replied to the invitation. She slows down her steps and goes to the corner of the street that is quieter and not many rushing passengers. Then, she checks the list more carefully. After that, she sends a short text message to report to Mike about the arrangement result before she confirms the invitation to the attendees.

The above described scenarios indicate that the users of MMS can be organizational workers moving dispersedly. The context of the scenarios tells that these users have experience of using web-based email system and outlook related meeting arranging system. They are familiar with mobile phone basic functions like making phone call and sending short text messages. The activities of performing tasks such as requesting Buddy List and querying for timeslot availability are obvious in the scenarios. The social and physical environment of MMS is self-explicit from the scenarios as well. Sometimes users are in meetings where silence is required when they need to operate the MMS in their phones. Some other times users are driving their cars when the MMS application requests attention. The scenarios show also that the technological environment of MMS is complicated. The S60 platform mobile phones have a great deal of variety. They vary a lot in shapes and screen sizes.